L9: Entry 6 of 6 File: USPT Oct 27, 1998

DOCUMENT-IDENTIFIER: US 5828370 A
**** See image for Certificate of Correction ****
TITLE: Video delivery system and method for displaying indexing slider bar on the subscriber video screen

Brief Summary Text (5):
Full-motion digital video requires a large amount of storage and data transfer bandwidth. Thus, video-on-demand systems use various types of video compression algorithms to reduce the amount of necessary storage and data transfer bandwidth. In general, different video compression methods exist for still graphic images and for full-motion video. Video compression methods for still graphic images or single video frames are referred to as intraframe compression methods, and compression methods for motion video are referred to as interframe compression methods.

Brief Summary Text (6):
Examples of video data compression for still graphic images are RLE (run-length encoding) and JPEG (Joint Photographic Experts Group) compression. The RLE compression method operates by testing for duplicated pixels in a single line of the bit map and storing the number of consecutive duplicate pixels rather than the data for the pixel itself. JPEG compression is a group of related standards that provide either lossless (no image quality degradation) or lossy (imperceptible to severe degradation) compression types. Although JPEG compression was originally designed for the compression of still images rather than video, JPEG compression is used in some motion video applications.

Brief Summary Text (7):
In contrast to compression algorithms for still images, most video compression algorithms are designed to compress full motion video. Video compression algorithms for motion video use a concept referred to as interframe compression, which involves storing only the differences between successive frames in the data file. Interframe compression stores the entire image of a key frame or reference frame, generally in a moderately compressed format. Successive frames are compared with the key frame, and only the differences between the key frame and the successive frames are stored. Periodically, such as when new scenes are displayed, new key frames are stored, and subsequent comparisons begin from this new reference point. It is noted that the interframe compression ratio may be kept constant while varying the video quality. Alternatively, interframe compression ratios may be content-dependent, i.e., if the video clip being compressed includes many abrupt scene transitions from one image to another, the compression is less efficient. Examples of video compression which use an interframe compression technique are MPEG, DVI and Indeo, among others.

Brief Summary Text (9):
A compression standard referred to as MPEG (Moving Pictures Experts Group) compression is a set of methods for compression and decompression of full motion video images which uses the interframe compression technique described above. MPEG compression uses both motion compensation and discrete cosine transform (DCT) processes and can yield compression ratios of more than 200:1.

Brief Summary Text (11):
An MPEG stream includes three types of pictures, referred to as the Intra (I) frame, the Predicted (P) frame, and the Bi-directional Interpolated (B) frame. The I or Intra frames contain the video data for the entire frame of video and are typically placed every 10 to 15 frames. Intra frames provide entry points into the file for random access, and are generally only moderately compressed. Predicted frames are

encoded with reference to a past frame, i.e., a prior Intra frame or Predicted frame. Thus P frames only include changes relative to prior I or P frames. In general, Predicted frames receive a fairly high amount of compression and are used as references for future Predicted frames. Thus, both I and P frames are used as references for subsequent frames. Bi-directional pictures include the greatest amount of compression and require both a past and a future reference in order to be encoded. Bi-directional frames are not used for references for other frames.

Brief Summary Text (12):
After the I frames have been created, the MPEG encoder divides each I frame into a grid of 16=16 pixel squares called macro blocks. The respective I frame is divided into macro blocks in order to perform motion compensation. Each of the subsequent pictures after the I frame are also divided into these same macro blocks. The encoder then searches for an exact, or near exact, match between the reference picture macro block and those in succeeding pictures. When a match is found, the encoder transmits a vector movement code or motion vector. The vector movement code or motion vector only includes information on the difference between the reference frame and the respective succeeding picture. The blocks in succeeding pictures that have no change relative to the block in the reference picture or frame are ignored. In general, for the frame(s) following a reference frame, i.e., P and B frames that follow a reference I or P frame, only small portions of these frames are different from the corresponding portions of the respective reference frame. Thus, for these frames, only the differences are captured, compressed and stored. Thus the amount of data that is actually stored for these frames is significantly reduced.

Brief Summary Text (14):
Each picture or frame also includes a picture header which identifies the frame and includes information for that frame. The MPEG standard also includes sequence headers which identify the start of a video sequence. Sequence headers are only required once before the beginning of a video sequence. However, the MPEG-2 standard allows a sequence header to be transferred before any I frame or P frame. The sequence header includes information relevant to the video sequence, including the frame rate and picture size, among other information.

Brief Summary Text (23):
In the preferred embodiment, the media server stores normal play streams, and may store one or more corresponding trick play streams, i.e., fast forward and/or fast reverse video streams, for each of the normal play streams. In the preferred embodiment, the media server stores normal play video streams which are preferably compressed using any of various types of video compression methods, preferably an MPEG method. The system of the present invention generates an index table or look-up table for each normal play stream which enables indexing to different positions in the stream. In creating an index table for a normal play stream, the system first analyzes the normal play stream and preferably creates a normal play time standard based on presentation timestamps comprised in the normal play stream. The system then preferably creates an index table or look-up table for the normal play stream using the normal play time standard. Each index table comprises an array of two-tuples, wherein the two-tuples are the normal play time standard and an index or offset into the respective stream. The index tables enable indexing to different locations in the stream. If the media server stores trick play streams, the system also preferably creates index tables for the trick play streams which enable indexing between the normal play and trick play streams.

Brief Summary Text (26):
The media server then uses the respective index table to index into the normal play video stream. After the media server calculates the new normal play time, the media server uses the calculated normal play time to retrieve the appropriate offset in the normal play stream index table. This offset is then used to begin play of the normal play stream at the retrieved offset. The set top box then preferably adjust the location of the knob on the slider bar to reflect the correct position of the video stream being output. The media server may also optionally examine the current normal play time and offset of the normal play stream being output in order to halt the normal play stream at an appropriate point before outputting the stream at the retrieved offset.

Brief Summary Text (27):
In one embodiment, when the user first manipulates the slider bar to jump to a new location in a video stream, the media server caches the current normal play time and byte offset of the normal play stream. Thus, if the user later desires to return to

the original point in the movie before any slider bar adjustments were made, the user presses a key on the remote control or selects a return option on the slider bar. This selection causes the media server to retrieve the appropriate normal play time and offset in the normal play stream index table. This offset is then used to being play of the normal play stream at the location where the stream originally was prior to any slider bar adjustments.

Detailed Description Text (6):
The normal play streams are preferably compressed video streams. The present invention operates independently of the type or format of the video streams. Thus the normal play video streams may be compressed in any of various types of formats, including MPEG-1, MPEG-2, Motion JPEG, QuickTime, etc. Further, the present invention operates independently of the frame rate and other presentation characteristics.

Detailed Description Text (8):
Referring now to FIG. 2, a diagram illustrating a user viewing a subscriber unit 52 according to the preferred embodiment of the present invention is shown. As shown, the subscriber unit 52 comprises a television or other display device 53. The television 53 includes a display screen 59 for displaying video images, as is well know in the art. It is noted that the television or display device 53 may comprise any various types of display units, including a digital TV or high definition TV (HDTV), a computer system having a video monitor, or other types of display devices.

Detailed Description Text (24):
As discussed above, an MPEG encoded stream includes a plurality of I-frames which are intracoded pictures, and a plurality of B and P frames which are interceded frames. The I frames each contain video data for an entire frame of video and are placed periodically in the sequence. The P and B frames include change information relative to prior or subsequent frames. Each picture or frame also includes a picture header which identifies the frame and includes information for that frame. An MPEG encoded stream further includes one or more sequence headers which include certain information regarding the video sequence, including the frame rate and the picture size, among other information. The sequence headers include presentation timestamps which indicate the play time of the video sequence.

Detailed Description Text (25):
In step 106 the system of the present invention preferably maps the presentation timestamps to a "normal play time" standard. Thus the system of the present invention defines a multimedia index based on the concept of "normal play time" that can be associated with a "position" within a multimedia title. The normal play time standard is used for indexing to different positions or locations in the normal play stream according to the present invention. The normal play time standard may also be used for indexing between streams having different presentation rates, i.e., for indexing between normal play and trick play streams. With regard to trick play streams, positions are defined to be equivalent between normal play and/or trick play video streams having different presentation rates when the content present at the respective position is conceptually substantially equivalent, i.e., when the same or substantially the same image in the sequence is being presented, allowing for differences in resolution and other encoding parameters that may be particular to the stream.

Detailed Description Text (28):
It is noted that other methods may be used to generate index tables for the normal play and trick play streams. In an alternate embodiment, the system of the present invention creates index look-up tables using a list of offsets to each GOP (Group of Pictures). In another embodiment, the system uses the presentation timestamps in the video stream for indexing. Other methods for creating the index tables may be used, as desired. It is also noted that other methods may be used to generate normal play time (NPT) standard index tables for the normal play stream

Detailed Description Text (29):
In step 108 the system creates an index look-up table for the respective multimedia normal play stream. The index look-up table for the normal play multimedia stream comprises an index or array of two-tuples, wherein each tuple comprises a normal play time value and an offset in the respective stream. If trick play streams exist in the system in step 110, the system optionally creates index look-up tables for the trick play streams in step 112. The index look-up tables for a normal play, fast

forward, and fast reverse stream are shown in FIG. 6. As shown, each tuple comprises a normal play time value and a corresponding file offset within the stream. For the normal play stream, the normal play time entries comprise the normal play time values computed in step 106. For trick play streams which have constant bit rate encodings, a scale factor is introduced into the normal play time values of the index look-up tables to compensate for the different presentation rates.

Detailed Description Text (30):
The index look-up tables specify indices or entries each based on a normal play time and a file offset to allow the multimedia server 50 to initiate or stop play at a particular normal play time point in the multimedia stream. The index look-up table for the normal play stream is used according to the present invention to enable the media server 50 to output video data for the normal play video stream at various locations or positions as indicated by user input to the slider bar 54. The index look-up tables for the trick play streams also allow the multimedia server 50 to transfer to and between equivalent positions of streams having different presentation rates, i.e., between normal play and trick play streams.

Detailed Description Text (31):
In one embodiment, the index look-up table only includes tuples representing valid positions for starting, stopping, or transferring between the streams. It is noted that equivalent positions in multimedia streams having different presentation rates will have equal NPT values, although the actual time of presentation from the beginning of the stream to that position will differ for the different streams. It is also noted that equivalent positions in multimedia streams having different presentation rates, although having equal NPT values, will have different byte offsets due to a presumptive difference in length of the streams having different presentation rates.

Detailed Description Text (32):
The creation of the look-up tables is independent of any particular type of video compression or MPEG representation. In the preferred embodiment where MPEG compression is used, the index look-up tables are created by scanning through the MPEG file, noting random access points in the MPEG file, and converting from the presentation timestamp in the MPEG file into the normal play time standard. Conceptually, each index table comprises an array of normal play time vs. scenes, and any particular image or frame in the movie can be identified by the normal play time value. As noted above, an index table is created for the normal play stream as well as any trick play streams, e.g., fast forward and fast reverse streams. Each of the offsets stored in the index table is an index from the normal play time to a byte offset in that MPEG file where the particular scene begins.

Detailed Description Text (33):
Therefore, in the preferred embodiment, the system of the present invention uses a normal play time standard for the index tables. In an alternate embodiment, the system of the present invention creates index look-up tables using a list of offsets to each GOP (Group of Pictures). As noted above, other methods for creating the index tables may be used, as desired.

Detailed Description Text (43):
After a new normal play time is determined based on the received user input in step 204, in step 206 the media server 50 indexes to a new position in the normal play stream based on the normal play time determined in step 204. Thus in step 206 the media server uses the normal play time calculated in step 204 to retrieve an offset from the normal play stream index table. In step 208 the media server 50 outputs the normal play stream at the indexed location or offset position determined in step 206.

Detailed Description Text (45):
Thus, a change in position or location of the output of a respective stream being output at a given normal play time is accomplished by finding the tuple in the respective index table for the nearest normal play time and utilizing the associated file offset as the point to initiate play of the stream.

Detailed Description Text (47):
Therefore, the present invention comprises a system and method which provides a graphical icon or slider bar for indexing to different positions or locations in a normal play video stream. The present invention examines the presentation timestamps in the sequence headers of the normal play stream and creates a normal play time

standard. The system then creates an index table or look-up table for the stream. The index table for the stream comprises normal play time values and corresponding offsets into the respective stream. During play, when the user manipulates or adjusts the slider bar knob, the subscriber device or set top box calculates a corresponding value and provides this value to the media server 50. The media server 50 uses the respective index table to intelligently jump or index to the appropriate position in the normal play stream and begin outputting the stream at this new position.

CLAIMS:

4. The method of claim 1, wherein the media server stores an index table corresponding to the video stream, wherein the index table comprising a plurality of tuples, wherein each of said tuples comprises a first value and a second offset value which is an offset into a position of the video stream, wherein said media server determining a new position of the video stream in response to said received user input comprises the media server indexing into the index look-up table to obtain an offset into the video stream.

5. The method of claim 4, wherein each of said plurality of tuples comprises a normal play time value and an offset into the video stream;

wherein said subscriber device providing information comprises the subscriber device providing a value within a predetermined range indicating a relative position within the video stream based on said received user input; and

wherein said media server determining a new output position for the video stream comprises the media server determining a normal play time value based on said received value in said predetermined range.

16. The interactive video delivery system of claim 15, wherein the media server further comprises:

a memory which stores an index table corresponding to the video stream, wherein the index table comprising a plurality of tuples, wherein each of said tuples comprises a first value and a second offset value which is an offset into a position of the video stream;

wherein said means for determining a new output position for the video stream indexes into the index look-up table stored in said memory to obtain an offset into the video stream.

17. The interactive video delivery system of claim 16, wherein each of said plurality of tuples comprises a normal play time value and an offset into the video stream;

wherein said means for providing information provides a value within a predetermined range indicating a relative position within the video stream based on said received user input; and

wherein said means for determining a new output position for the video stream determines a normal play time value based on said received value in said predetermined range.

25. The method of claim 24, wherein the media server stores an index table corresponding to the video stream, wherein the index table comprising a plurality of tuples, wherein each of said tuples comprises a first value and a second offset value which is an offset into a position of the video stream, wherein said media server determining a new output position of the video stream in response to said received user input comprises the media server indexing into the index look-up table to obtain an offset into the video stream.

27. The interactive video delivery system of claim 26, wherein the media server further comprises:

a memory which stores an index table corresponding to the video stream, wherein the index table comprising a plurality of tuples, wherein each of said tuples comprises a first value and a second offset value which is an offset into a position of the video stream;

wherein said means for determining a new output position for the video stream indexes into the index look-up table stored in said memory to obtain an offset into the video stream.

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☐ 1. Document ID: US 6556695 B1

L26: Entry 1 of 5 File: USPT Apr 29, 2003

US-PAT-NO: 6556695
DOCUMENT-IDENTIFIER: US 6556695 B1

TITLE: Method for producing high resolution real-time images, of structure and function during medical procedures

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☑ 2. Document ID: US 6081611 A

L26: Entry 2 of 5 File: USPT Jun 27, 2000

US-PAT-NO: 6081611
DOCUMENT-IDENTIFIER: US 6081611 A

TITLE: Aesthetic imaging system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
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☐ 3. Document ID: US 5978523 A

L26: Entry 3 of 5 File: USPT Nov 2, 1999

US-PAT-NO: 5978523
DOCUMENT-IDENTIFIER: US 5978523 A

TITLE: Method and apparatus for detecting modifications to aesthetic images

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☐ 4. Document ID: US 5854850 A

L26: Entry 4 of 5 File: USPT Dec 29, 1998

US-PAT-NO: 5854850
DOCUMENT-IDENTIFIER: US 5854850 A

TITLE: Method and apparatus for selectively illustrating image modifications in an aesthetic imaging system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
Draw Desc | Image

☑ 5. Document ID: US 5825941 A

L26: Entry 5 of 5 File: USPT Oct 20, 1998

US-PAT-NO: 5825941
DOCUMENT-IDENTIFIER: US 5825941 A

TITLE: Aesthetic imaging system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | KWIC
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DOCUMENT-IDENTIFIER: US 6081611 A
TITLE: Aesthetic imaging system

Abstract Text (1):
Disclosed is an aesthetic imaging system (20) for use in editing digital images. The aesthetic imaging system includes an imaging program (21) that runs on a personal computer (28) having an image capture board (30), a monitor (32), a video source (34) for providing digital images to be edited by the aesthetic imaging system, and a pen and tablet 38 for use in

Abstract Text (2):
editing the images. The imaging program includes a unique combination draw tool that includes a freehand draw mode, a curve mode and an undo mode that are available without cycling through menus. The combination draw tool may be used with any of the draw tools. Another feature of the imaging program is autoblend, a rectangular user interface that is invoked by each of the shape tools. The autoblend interface simplifies editing when using shape tools by consolidating the move, paste and blend, and paste without blending commands into a single, convenient interface.

Brief Summary Text (5):
People are with increasing frequency consulting physicians about cosmetic surgery. While in many cases the patients considering cosmetic surgery have an impressive understanding of the procedures available and medical terms used to describe these procedures, it is apparent that the slightest miscommunication may result in dire consequences. This has promoted the use of computer imaging to facilitate communication between the physician and prospective patient. Specifically, high-end aesthetic imaging systems allow a physician to take pre-operative digital images of the patient, e.g., including profile and frontal views. The images are stored in memory in the computer where they can then be edited. Using feedback from the patient, the edited images are useful in fully understanding the procedures desired. The visual support provided by a computer-based imaging system is extremely valuable on both sides. A cosmetic surgeon can more readily understand what patients hope to achieve by a cosmetic surgical procedure; and patients can view a detailed visual representation of predicted results, including both the benefits and limitations of the procedure.

Brief Summary Text (6):
Existing aesthetic imaging systems typically use a number of tools to allow a physician to manipulate a pre-operative image of a patient to illustrate an intended post-operative result. Preferably, the tools allow the physician to manipulate the preoperative image during a consultation with a patient. By manipulating the image with the patient in attendance, the patient receives immediate feedback from the displayed results. For a successful preoperative consultation, the use of the editing tools should be as unobtrusive as possible. During the consultation, a physician would like the patient to focus on the end results of the surgery, rather than the technologic wizardry used to demonstrate those results on the video monitor. Unfortunately, the editing tools used in existing aesthetic imaging systems typically hinder rather than help the physician in demonstrating the results that may be achieved through cosmetic surgery.

Brief Summary Text (7):
Among others, a disadvantage of existing aesthetic imaging programs is that a physician or facilitator in a pre-operative consultation typically must go back and forth through many windows-based menus in order to edit an image. Cycling between the various menus to invoke the tools necessary for a consultation is

disadvantageous in that it is time consuming. For example, some physicians schedule a follow-up visits for patients to allow the physician time to edit the images. More important, however, is that the process is distracting to the patient and tends to make the pre-operative consultation all the more mystifying. As a result of the disadvantages associated with prior art systems, some patients lose interest or become frustrated with the interview, both of which may reflect back on the physician.

Brief Summary Text (8):
A further disadvantage of existing aesthetic imaging systems is that it is impossible for a physician or facilitator to display different combinations of the edits that they have performed. In existing aesthetic imaging programs, as a physician edits a patient's image, the physician's edits are added to the preexisting edits of the image. Most programs are only capable of showing two version of the patient's image; the unedited, original version, and the final edited version incorporating all of the physician's changes. It is therefore difficult for the physician to show various combinations of the edits that had been performed. For example, a physician may edit an image to remove wrinkles around a patient's eyes and to narrow the patient's nose. Existing aesthetic imaging programs only allowed the physician to simultaneously show all of these changes. If, for example, the patient wished to view the changes to the eyes without the changes to the nose, it was difficult for the physician to easily separate out the sequence of edits that had been performed to adjust the patient's nose. An improved aesthetic imaging system in which a physician can more easily edit pre-operative images in response to a patient's suggestions and inquiries would be extremely advantageous.

Brief Summary Text (9):
A still further disadvantage of existing aesthetic imaging systems is that the systems allow a physician to perform nearly flawless editing of a patient's image. Unfortunately, the edits performed by a physician on an aesthetic imaging system are often unobtainable results that cannot be achieved when actual surgery is performed. Unless the physician is especially skilled at using the aesthetic imaging system, it is difficult to show the patient achievable results, which typically fall within a range somewhere between the original patient image, and the optimum results as displayed by the edited image on the screen. It therefore would be advantageous to develop an aesthetic imaging system that allowed a physician to display more realistic results that are achievable through surgery.

Brief Summary Text (11):
The invention is an aesthetic imaging system for use in editing digital images. The aesthetic imaging system includes a unique user interface that allows edits to be performed more efficiently and with less confusion to the patient.

Brief Summary Text (12):
In one aspect of the invention, a method of editing a digital image comprised of a plurality of color pixels in an aesthetic imaging system is disclosed. The aesthetic imaging system including a processor, a memory, a monitor, and a pen and cooperating tablet for controlling a cursor displayed on the monitor. The pen has a depressable tip and a side button, each of which include an on status and an off status, wherein the position of the pen tip relative to the tablet determines the position of the cursor on the monitor. The method comprises: (a) evaluating the following variables: (i) the status of the tip of the pen; (ii) the status of the side button on the pen; and (iii) movement of the pen tip relative to the tablet; (b) actuating a freehand drawing mode if a first set of variables are present, wherein movement of the pen relative to the tablet edits pixels that are located at positions corresponding to the position of the cursor; and (c) actuating a curve drawing mode if a second set of variables are present, wherein a line segment is displayed between two endpoints and movement of the pen relative to the tablet stretches the line segment, forming a curve and editing pixels that are located at positions corresponding to the position of the curve.

Brief Summary Text (16):
In another aspect of the invention, an improved prioritize feature is described for viewing an image. A user may identify several areas in a modified patient image containing edits that alter the image from the original image. As each area is identified by the user, an identifying tag is assigned to each of the areas. When desiring to show various combinations of the edits that have been performed on the image, the user may select the areas to display using the identifying tags. A user may therefore quickly cycle through various permutations of the procedures that have

been edited for patient display.

Brief Summary Text (17):
In still another aspect of the invention, an improved user interface is provided to minimize the distraction of a patient as the patient is watching the image being edited. Preferably, a menu bar on the top of the display is removed during most editing, so that only the image of the patient is displayed. When the menu bar must be displayed, the bar itself is transparent to allow the patient to see the image-through the menu bar. Only the commands and the outline of the menu bar are presented in a contrasting color, minimizing the overall visual impression created by the menu bar.

Brief Summary Text (18):
In yet another aspect of the invention, a warp tool is described that allows a user to quickly and easily manipulate various features in an image. To use the warp tool, a user first encircles a portion of the image to be edited. Once the area has been selected, the user may tip the pen to designate a stretch point within the selected area. As the user floats the pen over the tablet, the image is then stretched as if pulled from the stretch point. Areas of the image in the direction of stretch are compressed, and areas away from the direction of stretch are expanded. Areas surrounding the warping area are automatically adjusted to ensure that there is no discontinuities with the warping area. The manipulation of the image is performed in real-time, allowing a patient to see the warping as it is being performed by a user.

Brief Summary Text (19):
An advantage of the tools and features described herein are that they improve the overall experience of a patient during a preoperative visit with a physician. The powerful tools in the aesthetic imaging system allow the physician to easily manipulate the patient's image in response to feedback provided by the patient. The aesthetic imaging system interface also allows the patient to focus on the image being manipulated, rather than on the aspects of the aesthetic imaging system that allow the manipulation. The end result is an improved preoperative visit that provides a more realistic impression of the results that a physician may achieve through surgery.

Drawing Description Text (5):
FIG. 3 is a flow chart illustrating an exemplary routine by which digital images may be viewed and edited using the aesthetic imaging system;

Drawing Description Text (7):
FIG. 4B is a flow chart of an exemplary routine for calculating a checksum value and comparing the calculated value to a previously stored value to determine if an image has been altered;

Drawing Description Text (9):
FIG. 6 is a pictorial representation of an image to be edited;

Drawing Description Text (10):
FIGS. 7A-7E are pictorial representations of editing an image using a prior art imaging program;

Drawing Description Text (19):
FIG. 13 is a flow chart of an exemplary routine for viewing images in accordance with the invention;

Drawing Description Text (21):
FIGS. 15A-15C illustrate a split image option of viewing images in accordance with the invention;

Drawing Description Text (22):
FIG. 16 is a pictorial representation illustrating the use of a translucent image to allow a patient to accurately position themselves in order to capture a second image having the same location and orientation as an original stored image;

Drawing Description Text (23):
FIG. 17 is a pictorial representation illustrating a compare image wherein a presurgical image of a patient is compared side-by-side with a postsurgical image having the same location and orientation;

Drawing Description Text (24):
FIGS. 18A-18C are pictorial representations illustrating the use of a warp shape tool to edit a patient's image

Drawing Description Text (26):
FIG. 20 is a pictorial representation illustrating the use of a transparent menu bar when viewing an image of a patient; and

Detailed Description Text (4):
The aesthetic imaging system also includes an image capture board 30 that is coupled to the processing unit 22, a monitor 32, video source 34, and printer 36. The video source, monitor, and printer are coupled to the processing unit 22 through the image capture board 30. The video source may include one or more video cameras, a VCR, a scanner, or sinilar source for providing digital images to be edited by the aesthetic imaging system. The aesthetic imaging system further includes a pointing device, which is preferably a stylus (pen) and tablet 38, that is connected to the processing unit 22. In addition, the aesthetic imaging system may include a modem 40 to provide on-line capabilities to users of the system, such as technical support and teleconferencing.

Detailed Description Text (5):
The image capture board 30 has a plurality of buffers in high-speed memory, e.g., RAM, that are used by the imaging program 21 to provide very fast response times to image edits. With reference to FIG. 2, four buffers are illustrated for use in explaining the operation of the aesthetic imaging system. These include an original image buffer 50, a modified image buffer 52, a current image buffer 54, and a working buffer 56. Suitable image capture boards for use in the aesthetic imaging system include the Targa +64 and Targa 2000 boards, distributed by Truevision, Inc. of Indianapolis, Ind. The buffers are discussed in regard to a single pose only, such as a profile or front view of a person.

Detailed Description Text (6):
The original image buffer 50 contains an unedited digital image, for example, a side profile picture of a potential patient. The modified image buffer 52 contains any edits made to a copy of the original image. The modified image buffer is updated during a save and after each session. The current image buffer 54 contains information identical to the modified image buffer upon beginning a session. Thereafter, edits made to the current image are saved in the working buffer 56 as an overlay to the current image. During a save, the contents of the current image buffer 54 are copied to the modified image buffer 52, and the working buffer 56 is cleared.

Detailed Description Text (8):
Image

Detailed Description Text (9):
A digital photograph or picture of a patient.

Detailed Description Text (11):
The "pen" that may be used to select menus, modify images, and carry out other commands in the program. The stylus controls the cursor, just as a mouse pointing device does on a personal computer.

Detailed Description Text (23):
Pressing the tip of the pen, then dragging it across the tablet while maintaining pressure. When using drawing and shaping tools, this turns the cursor into a drawing tool, enabling the user to draw freehand objects or "brush" the image in any manner.

Detailed Description Text (25):
At block 64, a test is made to determine if the Camera option has been selected from the main menu, indicating that the user wants to take a picture of a patient. If the Camera option has been selected, a routine to implement this command is called at block 66. A suitable subroutine for this task in illustrated in FIG. 4. Upon return from the Camera routine, the program loops to block 62.

Detailed Description Text (26):
If the Camera option was not selected, a test is made at block 68 to determine if

the Storage option has been selected for the main menu, indicating that the user wants to load an image (picture) from computer storage, e.g., a hard drive. If the Storage option was selected, the image(s) to be edited or viewed during the current session are selected at block 70.

Detailed Description Text (27):
At block 72, the selected images are copied to the appropriate buffers in the frame grabbing board, as described in FIG. 2 and the accompanying text. For example, if the selected image is an original image that has not yet been edited, the original image will be copied to the original, modified, and current image buffers. If the selected image is an image that has previously been modified, the original image is copied to the original image buffer 50 and the modified image is copied to both the modified and current image buffers 52 and 54. It will be appreciated that the number of images that may be loaded at one time will be limited, in part, by the capacity of the frame grabbing board. The program then loops to block 62.

Detailed Description Text (30):
If the View option has been selected, a view subroutine is invoked at block 84. An appropriate routine for the View option is shown in FIG. 13. The program then loops to block 62. At block 86 a test is made to determine whether the Exit option has been selected from the main menu. If not, the program loops to block 62. Otherwise, any edits to the image are saved at block 88. At this point in the program, the image in the current image buffer 54 is saved to the modified image buffer 52, and the working buffer 56 is cleared. The program then terminates.

Detailed Description Text (31):
Taking Pictures of a Patient Using an Inverse Image

Detailed Description Text (32):
FIG. 4A illustrates an exemplary user interface that utilizes a video camera for acquiring a digital image of a patient. It is noted a scanner or other input device may also be used to input an image into the aesthetic imaging system. In FIG. 4A, the solid blocks indicate user interface options presented to the user by the aesthetic imaging system and the dashed blocks represent system responses to the decisions made. At block 100, a patient is positioned in front of the video-camera. In a preferred embodiment of the aesthetic imaging system, an inverse or "mirror" image of the patient's image will be displayed on the monitor, as indicated at block 101. The inverse image is computed using data from the original image, and is representative of how patients see themselves day to day when looking into a mirror. More specifically, digital images are comprised of pixels or picture elements. It is known to those skilled in the art how digital image pixels may be manipulated to create an image that is the inverse of the original.

Detailed Description Text (33):
Displaying an inverse image of a patient is advantageous when taking pre- and post-surgical pictures of patients because it allows patients to more easily center or otherwise position themselves on the monitor. Without the pixel manipulation, the input from a camera or other digital device may create confusion when positioning a patient. Under normal viewing, if a patient appears left of center in the monitor, they are in reality too far to the right. In this instance, a typical patient's reaction is to move even further to the right. With a mirror image displayed, the tendency of most patients is to naturally adjust to the desired position.

Detailed Description Text (34):
The displaying of a mirror image is particularly important when taking post-surgical pictures. In post-surgical pictures, it is advantageous to have the patient in exactly the position they were in when taking the pre-surgical picture. For post-surgical pictures, the aesthetic imaging system will preferably display a translucent inverse image of the pre-surgical picture on the monitor, and then overlay an inverse image of the picture currently being taken. As shown in FIG. 16, a translucent patient image 370, in this case a patient's profile, is displayed on the monitor. The translucent image is the preoperative image taken prior to undergoing a surgical procedure. A "live" video image 372 of the patient is also displayed under the translucent inverse image. By moving the relative positions of the patient and the camera, a user may position the patient in the identical orientation with which they took the presurgical picture. When the patient is appropriately positioned, the tip of the pen may be pressed anywhere on the tablet to freeze the digital image on the monitor. Patients can thus easily align themselves with their former picture to achieve very similar before and after

pictures.

Detailed Description Text (35):
The advantage of the translucent method of aligning a patient is shown in the side-by-side display shown in FIG. 17. As shown in FIG. 17, the aesthetic imaging system of the present invention may generate a side-by-side display of the two images to allow a patient to easily and accurately compare a presurgical picture with a post-surgical picture. The left half of the monitor may display the presurgical image 370, and the right half of the monitor may display the post-surgical image 372. Allowing a patient to view the two images side-by-side in precisely the same orientation provides the patient with an accurate impression of the results achieved by surgery.

Detailed Description Text (36):
Upon establishing a desired position for the patient, the image is focused and sized at block 102 by using the aesthetic imaging system to adjust the electronic controls on the video camera. After any adjustments have been made to the camera, at block 104 the tip of the pen is pressed anywhere on the tablet to freeze the digital image onto the monitor. At block 106, the user makes a determination if the image currently displayed on the monitor is acceptable. If the image is not acceptable, the routine loops to block 100. If the image is acceptable, an appropriate command is entered at block 108 and the image is stored in nonvolatile memory for future viewing.

Detailed Description Text (37):
At block 110, a test is made to determine if an exit or other similar command has been entered by the user, i.e., if any more pictures are to be taken. If additional pictures are to be taken, the program loops to block 100. Otherwise, at block 111 a checksum value (described below) is calculated by the imaging program for each (original) image that has been stored. At block 112, the imaging program stores each image and its associated checksum value. The routine then returns to block 68 of FIG. 3.

Detailed Description Text (38):
Determining Authenticity Using Checksum Values The checksum value is an addendum to an original stored image that is used to determine its authenticity when the image is subsequently displayed or printed. Those skilled in the art will recognize that there are a number of methods of implementing such a checksum procedure. For example, one checksum computation is to add up the grayscale values for one of the colors, i.e., red, green, or blue, for each pixel comprising the image. Assuming a screen of 640 by 480 pixels and 256 colors per pixel, the checksum values would range from 0 to (640)(480)(255). When an image is recalled for display or to be printed, the checksum value is recalculated. If the image has not been modified, the newly calculated checksum value will be equivalent to the addendum value, and the image is certified as being unaltered. If the image has been modified, the checksum values will vary, indicating the image has been modified. In this instance, an indication of the fact that the image has been modified may be displayed or printed with the image, if desired.

Detailed Description Text (39):
The authentication of an original image using a checksum value is ideal for situations in which physicians display before and after pictures of a patient who has undergone cosmetic surgery. In some instances, viewers are skeptical as to whether an "after" image is really representative of a patient's appearance after surgery. This is in reaction to beliefs that post-surgical images have been altered to make the patients look better. For example, there may be temptation to slightly fade wrinkles or otherwise edit features that the physician was attempting to address in a surgery.

Detailed Description Text (40):
Using the described checksum feature, the post-surgery image can be verified as an authentic, unaltered image based upon the addendum value, and the veracity of the image is not questioned. This is beneficial to physicians when illustrating post-surgical results during lectures or in other teaching situations.

Detailed Description Text (41):
FIG. 4B illustrates an exemplary routine for determining whether or not an original image, i.e., pre- or post-surgical image, has been altered in accordance with the invention. This routine may be invoked whenever a pre- or post-surgical image is

displayed on a monitor or printed on a page. At block 114, a test is made to determine whether the image to be displayed is portrayed as an "original image" that was not modified, e.g., a before or after picture. If the image is supposed to be an original image, a current checksum value for the image is calculated at block 115. At block 116, the calculated checksum value for the image is compared to the checksum that was stored when the image was acquired by the aesthetic imaging system, e.g., when the picture was taken.

Detailed Description Text (42):
At block 117, the calculated checksum value is compared to the stored checksum value to see if they are equivalent. If the two values are not equivalent, at block 118 an icon is added to the image, e.g., displayed or printed along with the image, indicating that the image has been altered. If the checksum values are equivalent, an icon is added to the image at block 119 verifying the authenticity of the image. Once either icon has been added to the image, or if the image being printed or displayed is not an original image, the program terminates. As will be appreciated, the same checksum computational method must be used on each image, i.e., when an original image is acquired and when an image is to be displayed, or the comparison will be meaningless.

Detailed Description Text (43):
While the use of a checksum is contemplated in the exemplary routine for determining whether an original image has been altered, it will be appreciated that other techniques may be used to detect when an original digital image has been modified. For example, a flag or other marker may be uniquely associated with the original digital image. If the flag or other marker is absent from the digital image being displayed, the digital image is a copy that is presumed to have been changed.

Detailed Description Text (44):
Alternatively, two versions of the image may be stored, included an unaltered original and a copy. The two images may be compared in order to determine whether modifications have been made to the copy.

Detailed Description Text (47):
A disadvantage of prior art aesthetic imaging systems is that a physician or facilitator may have to cycle back and forth between several menus in order to properly edit an image. In an effort to minimize the number of menus required, the imaging program includes a unique combination draw (CD) feature that generally works with all of the drawing tools. The CD feature allows a user to freehand draw, use curves to edit an image, as well as undo using either freehand or curves, without having to invoke a separate menu for each item.

Detailed Description Text (49):
To freehand draw, the user presses on the tablet with the pen tip and continues pressure while moving or "rubbing" the pen on the tablet. At this point the chosen color is written onto the image at the location on the monitor that corresponds to the pen location. Pressing the side bar while repeating the motion will allow the user to selectively remove any edits to the image using a freehand motion.

Detailed Description Text (50):
To draw a curve, the user must set a first anchor point by selecting with the pen. Thereafter, as the user moves or "floats" the pen across the tablet, a green line will extend from the first anchor point to the current position of the pen. In a desired location, a second anchor point is set by selecting with the pen. Once both anchor points have been established, the green line appears on the monitor as a segment between the two anchor points. To create a curve, the user floats the pen across the tablet. The system will display a curved line bending and moving with the movement of the pen. The pen movement (top to bottom, or side to side) determines the arc of the curve. As the curve moves across the image, the image is edited in accordance with the selected draw tool and draw tool options. With the airbrush example, the system displays the curved line repeating itself with the chosen color. Pressing the side bar while repeating the motion will allow selective removal of any edits to the image using a curve established between the anchor points.

Detailed Description Text (53):
If the side button has not been pressed, a test is made at block 126 to determine if the tip of the pen has been pressed. If the tip has not been pressed, the routine loops to block 124. Otherwise, a test is made at block 128 to determine if the tip was released prior to moving the pen. If the pen has been moved while the pen tip

was pressed against the tablet, the imaging program enters freehand draw mode, shown at block 130. In one embodiment of the invention, freehand draw mode is entered if the pen moves the equivalent of three or more pixels. While in freehand draw mode, freehand edits may be made to the image in a manner similar to prior art imaging programs. This mode will remain until pressure on the pen tip is released. After beginning freehand draw mode, the routine loops to block 124.

Detailed Description Text (58):
To further exemplify the advantages of the CD draw tool described in FIG. 5, an original (unedited) image 130 that is representative of an image displayed on a monitor is illustrated in FIG. 6. A main menu 132 is displayed across the top of the image to allow a user to select editing, viewing and printing options, as discussed in FIG. 3 and accompanying text. The main menu 132 is from an embodiment of the aesthetic imaging system 20.

Detailed Description Text (59):
FIGS. 7A-7E and 8A-8E contrast exemplary steps taken to make identical edits to the image 130. The steps required to modify the image using a relatively advanced prior art imaging system are illustrated in FIGS. 7A-7E. These steps are modeled after a prior art imaging system that has been distributed by Mirror Image Technology, Inc., a division of Virtual Eyes, Incorporated, the assignee of the present invention. The steps required using an embodiment of the aesthetic imaging system 20 in accordance with the invention are illustrated in FIGS. 8A-8E. Briefly, each set of drawings illustrates examples of edits to a patient's nose, chin, and neck regions. The edits are for use in explaining the invention only, and merely exemplary in nature.

Detailed Description Text (143):
FIG. 9A illustrates a user interface for a contour tool for use in editing images in accordance with the invention. The contour tool is invoked from the main menu of the imaging program, as indicated at block 200. The contour tool has similarities to a blend tool, but utilizes pixel manipulation to pull pixels from one area to another. For example, the tool works great for chin and lip augmentations.

Detailed Description Text (147):
FIGS. 9B-9C further describe the operation of the contour tool, by illustrating how pixels are replicated from one area of an image to another. The image areas described are for exemplary purposes only, and are simplified for clarity in this discussion. With reference to FIG. 9B, an area 209 of an image is comprised of red 218R, green 218G, blue 218B, and yellow 218Y areas separated by boundary lines 210, 212, 214, and 216. It is assumed that a pair of anchor points 218 and 219 have been established by a user along the boundary 212, wherein the aesthetic imaging system will display a line segment 220 between the two anchor points.

Detailed Description Text (150):
If the opacity level is less than 100 percent, pixels from the underlying image areas that are being written over by the newly defined areas will be blended into the newly defined areas. At an opacity of 80 percent, for example, the area bounded by segments 220 and 221 will still be primarily blue, but the portion of this area bounded by the segment 220 and the boundary line 214 may have a yellow tinge; and the portion of this area bounded by the boundary line 212 and segment 221 may have a green tinge. As the opacity percentage is dropped, the effects on these areas will be even greater.

Detailed Description Text (153):
FIG. 9D is a "before" picture without any modifications. To edit the right half of the patient's upper lip, the user first selects the desired end points surrounding the feature to be modified. A first anchor point 374 is designated near the middle of the upper lip, and a second anchor point 376 is designated at the right outer margin of the upper lip. When the anchor points have been selected, a line 378 is displayed between the points by the aesthetic imaging system. By floating the pen over the tablet in a direction generally indicated by arrow 380, the line is bent to form a curve 382 that approximates the contour of the feature being edited. When the user has fitted the curve to the feature, the shape of the curve is set by tipping the pen. As shown in FIG. 9E, the user then selects a point along the portion of the curve by tipping the pen at the desired location. By floating the pen above the tablet, the user can stretch the selected feature in the manner described above. In FIG. 9E, the user floats the pen in a direction generally indicated by arrow 384 to enlarge the patient's right upper lip. As the upper lip is expanded, the pixels forning the upper lip are replicated to expand the portion of the lip, while the

pixels outside of the upper lip are deleted.

Detailed Description Text (158):
The black dots are brush size options that allow a user to choose the thickness of a shaping tool. The zoom option allows a user to look at an image in greater detail. When the zoom option is invoked, the aesthetic imaging system displays a square overlaid on the image. The square can be positioned by the user with the pen. After positioning the square, that area of the image will be magnified when the pen is selected. Canceling with the pen will display normal viewing mode. The undo option allows a user to undo edits to an image. The compare option allows a user to transition between before and after images. The split image option allows a user view before and after images side by side. The inverse option creates the mirror image of all or only a portion of an image that has been designated by the user. The blend tool will blend edits with the surrounding area. Many of the options shown are also implemented as separate tools under View in the main menu. These are described in greater detail below.

Detailed Description Text (160):
At block 232, the user is prompted to designate an area of the image to be edited. In a preferred embodiment, this is accomplished by pressing down on the pen and freehand drawing an area, e.g., a circle, that is to be subject to the edit. In this regard, the imaging program contains a unique feature wherein if a partial area is designated and the pen subsequently released, the drawing area will automatically be formed into a contiguous area by the imaging program. At block 236, a test is made to determine if an area has been designated by the user. If not, the routine loops back to block 234 and awaits a designation.

Detailed Description Text (161):
After an area has been designated, any edits to the designated area of the image are performed in accordance with the selected shape tool, as indicated at block 236. Two exemplary shape tools for editing an image are illustrated in FIGS. 12A and 12B. At block 238, a test is made to determine if editing of the designated area is complete. In one embodiment, this involves testing for when the user "selects" with the pen anywhere on the tablet. The routine remains at block 238 until editing is complete (or the user exits using the side button). Upon completion of the edits, an autoblend box is displayed in the vicinity of the edited area, as indicated at block 240.

Detailed Description Text (163):
FIG. 11 illustrates an example of an autoblend box 250 that may be drawn by the aesthetic imaging system in accordance with the invention. As is discussed above, the autoblend box 250 may be used to: (1) move an edited area, (2) paste the edited area onto the image while blending the edge created between the edited area and the rest of the image, and (3) paste the edited image without blending. While the autoblend box 250 uses the conventions set forth below, those skilled in the art will appreciate that other conventions may be used without departing from the scope of the invention.

Detailed Description Text (165):
With reference again to FIG. 10, a test is made at block 244 to determine if the pen tip has been pressed at a location outside of the autoblend box. If the pen tip was pressed at a location outside the autoblend box, the edit area is pasted with a blending of the edges at block 260. Otherwise, a test is made at block 262 to determine if the tip location was within the approximate three-, six-, nine-, and twelve-o'clock areas of the autoblend box. A pressing of the tip within any of these areas results in the edited area being pasted without blending, as indicated at block 264. As indicated at block 266, a selection in a location in the autoblend box apart from the three-, six-, nine-, and twelve-o'clock areas will allow the image to be moved. In this case, the edited area will track movement of the pen as long as the tip remains pressed, After a move is completed, the routine loops to block 242.

Detailed Description Text (166):
If a paste has been accomplished using blocks 260 or 264, a test is made at block 268 to determine if the user wishes to exit the shape routine, e.g., by pressing the side button. If not, the routine loops to block 232 where a new area of the image may be considered. Otherwise, the routine returns to block 82 of FIG. 3.

Detailed Description Text (167):
FIGS. 12A and 12B illustrate two exemplary shape tools that are available when using

the aesthetic imaging system. With reference to FIG. 12A, a cutout tool is unique in that a user can select an area of the image to be cut out, thereby creating a "hole" in the image, and an identical image underneath the cutout image can then be moved in all directions as it is viewed through the hole. The cutout feature is especially useful for profile views including chin augmentation, brow lifts, and maxillary and mandibular movement; and frontal views, including otoplasty, brow lift, lip augmentation, nasal base narrowing, and maxillary and mandibular movement.

Detailed Description Text (168):
At block 270, the current image is copied to a working buffer. As is discussed in FIG. 10, when the cutout subroutine is called the user has defined an area of the image to be edited. At block 272, a boundary is created around the designated area designated in block 234 of FIG. 10. At block 274, the working area is displayed inside the boundary, and the current image displayed outside the boundary. In this manner, the image in the working buffer can be moved relative to the image in the current buffer until the desired alignment has been achieved. The program then returns to the routine of FIG. 10.

Detailed Description Text (170):
With reference to FIG. 12B, a rotate tool in accordance with the invention is particularly useful when editing profile views including the nasal tip, mandible, maxilla and brow areas; and frontal views including nares, brows, and the corners of the mouth. As is discussed in FIG. 10, when the rotate routine is called, the user has defined an area of the image to be edited. At block 276, the area designated in block 234 of FIG. 10 is shown in phantom. At block 278, the imaging program waits for the user to enter an axis of rotation. An axis is then entered by the user, as indicated at block 279.

Detailed Description Text (171):
Once an axis of rotation is entered, a display line emanating from the axis point is displayed on the monitor, as indicated at block 280. Also, the number of degrees of rotation is displayed. The position of the pen dictates the degree of rotation. As the pen is moved away from the axis point, the display line will lengthen, providing the user greater control of the rotation of the designated area. At block 282, the system waits for the user to enter a desired degree of rotation. The degree of rotation is entered by the user by selecting with the pen, as indicated at block 283. Once the degree of rotation is entered, the designated area is redrawn onto the current image, as indicated at block 284.

Detailed Description Text (174):
FIGS. 18A-18D disclose the capabilities of the warp shape tool in the aesthetic imaging system. The warp shape tool is a powerful tool that allows users to easily edit a patient's features. Similar to the contour tool, the warp tool allows a user to select and manipulate a feature of the patient's image, with the aesthetic imaging system automatically redrawing the area surrounding the manipulated feature as the manipulation is being performed.

Detailed Description Text (175):
As shown in FIG. 18A, the user first defines an image to be manipulated by the warp tool by encircling the portion of the image to be edited as shown by dotted line 386. Once the area has been selected, a user may tip the pen to designate a stretch point within the selected area. As shown in FIG. 18A, a stretch point 388 has been designated near the top portion of

Detailed Description Text (176):
the patient's right upper lip. Once the stretch point has been designated, the user may float the pen in the desired direction that they would like to stretch the image. The portion of the image that is located at the stretch point is pulled in the direction that the user floats the pen, with the area surrounding the stretch point either expanded or compressed. That is, the area in the direction that the user floats the pen is compressed, and the area away from the direction that the user floats the pen is expanded. The amount of expansion or compression is dictated by the distance of the area away from the stretch point, in a manner discussed in greater detail below. Preferably, the image is manipulated in real time, so that the user is presented with a seamless and continuous stretching or movement of the selected feature.

Detailed Description Text (180):
When the desired warping effect is achieved, the user tips the pen to fix the

stretch point in a desired location. To ensure there is no discontinuity between the manipulation area and the surrounding area of the patient's image, automatic blending around the outer margins of the manipulation area is performed by the aesthetic imaging system. As shown in FIG. 19E, the aesthetic imaging system also remaps the warping area, creating four new rectangles 436a, 436b, 436c, and 436d based on the ending location 438 of the stretch point. In a preferred embodiment of the invention, a second stretch point may then be selected within the manipulation area and the process repeated, with the second warping transforming rectangles 436a, 436b, 436c, and 436d that resulted from the first warp. After the second warping is completed, the user may then select a third or additional warp point to further manipulate the image. Each manipulation is performed without the user having to redefine the manipulation area.

Detailed Description Text (182):
The warp tool with multiple stretch points is a very powerful tool as it allows the user to quickly manipulate an image with a minimum use of drawing tools or piecemeal editing. Because the warp tool performs the manipulation in real-time, the edits are accomplished very quickly and fluidly. A user may therefore generate a desired image in a minimal amount of time.

Detailed Description Text (183):
Viewing an Image

Detailed Description Text (184):
FIG. 13 illustrates an exemplary routine for implementing the view features of the imaging program. In FIG. 13, the solid blocks indicate user interface options presented to the user by the aesthetic imaging system and the dashed blocks represent system responses to the decisions made. The view group includes: Compare, Prioritize, Split Image, Mirror Image, and Restore to Original, as well as other options including Zoom and Emboss. At block 300, a test is made to determine if the Compare option has been selected.

Detailed Description Text (185):
The Compare option allows a modified image to be compared to the original image so that a viewer can more readily see the changes. Specifically, as the pen is floated from the top to the bottom of the tablet, the user will see one image transition or "morph" into the other. The morphing is accomplished by overlaying the original image with the modified image, and varying the opacity of the modified image. When the modified image is opaque, only the modified image may be viewed by a user. When the modified image is completely transparent, only the original image may be viewed by a user. In between these two extremes, varying amounts of the edits made to the image will be apparent to the user. The feedback to the patient as the original image morphs into the modified image is much more powerful than a side-by-side comparison of the two images.

Detailed Description Text (186):
When a desired comparison level is achieved, a user can press the tip of the pen to freeze an image displayed on the monitor at a point anywhere from zero to 100% of the transition from the original to the modified image. Freezing an image at a partial transition is extremely helpful where edits have been performed on an image that are not realistically achievable in surgery, but an achievable result lies somewhere between the original and the modified image. For example, it is easy to edit a blemish on a face so that area resembles the surrounding skin and thus becomes invisible. However, the total removal of the blemish may not be realistic. In this case, a transition of that area toward the original image will slowly "fade in" the blemish. A physician may then freeze the fading process at a desired point to provide a realistic image of what surgery can achieve to the patient.

Detailed Description Text (187):
Another option that is a subset of the Compare option is the Prioritize option. The Prioritize option allows a user to designate areas that have been edited so that the user can selectively illustrate the effects of two or more procedures that have been shown to a patient. For example, FIG. 14A illustrates a modified profile image 302 of a patient that includes a rhinoplasty procedure (nose) 304, a chin augmentation procedure 306 and a submental lipectomy procedure (neck) 308. The boundaries that have been edited are illustrated by dashed lines 304a, 306a, and 308a, corresponding to the patients original nose profile, chin, and neck, respectively. Using the Prioritize option, the user can designate one area on the modified image, and illustrate transitions between the original and modified images at that area only by

floating the pen. Any areas not selected will continue to be displayed as the original image.

Detailed Description Text (188):
With reference again to FIG. 13, if the Compare option has been selected, a test is made at block 309 to determine if the entire image is to be compared or only certain portions of the image, i.e., using the Prioritize option. If less than the entire image is to be compared, the user is prompted to enter the area or areas that are to be compared at block 310. A user may then define one or more "priority areas" by freehand circling the desired area. When the priority areas or defined, or if all of the edits are to be reviewed during the comparison, at block 311 the user is prompted to float the pen in a vertical motion on top of the tablet to transition between the original and modified images, in accordance with the Compare feature discussed above. An illustration will clarify this point.

Detailed Description Text (189):
In FIG. 14B, a first priority area 312 has been defined that corresponds generally to the nose. Given this selection, the nose area only will transition from original to modified as the pen is moved, with the rest of the image being displayed unedited. Thus, the modifications to the chin and neck no longer are shown. In FIG. 14C, a second priority area 314 has been defined that corresponds generally to the chin. The first priority area 312 has been kept. Given these selections, the nose and chin areas only will transition from original to modified as the pen is moved, with the rest of the image being displayed unedited. Thus, the modifications to the neck are not illustrated.

Detailed Description Text (190):
With reference to FIG. 14D, a third priority area 316 has been defined that corresponds generally to the neck, along with the former designations. Given these selections, all three priority areas 312, 314, and 316 transition with movement of the pen. Again, the undesignated portions of the image are displayed in an unedited form, even if parts of the image outside the priority areas have been edited (no edits are shown). Because edits have not been made, from a user's standpoint the transition in FIG. 14D appears to be a comparison between the original and modified images.

Detailed Description Text (191):
While preferably the user defines the priority areas on the image being edited, it will be appreciated that the priority areas may also be automatically defined by the aesthetic imaging system. A comparison may be made between an original image stored in a buffer and the edited image that has been modified by the user. Any areas containing differences between the original and the edited image may be highlighted by the aesthetic imaging system, and a priority area automatically defined for each area containing differences. Whether a priority area is defined may also depend on the number of differences between the original image and the edited image.

Detailed Description Text (193):
In the alternative embodiment in which textual identifiers are assigned to each of the priority areas, it will be appreciated that various methods can be used to display to the user the correspondence between the textual identifier and the priority area. For example, when the user selects one of the textual identifiers, the priority area could be highlighted or otherwise encircled with a contrasting color to indicate to the user the area of the image that corresponds to that textual identifier. Similarly, a user may also point to specific areas of the displayed image and have the textual identifier corresponding to that area appear to the user. Displaying the correspondence between priority area and identifier would allow a user to rapidly determine the available priority areas that may be shown to a patient when the user has not recently worked with or otherwise viewed the image.

Detailed Description Text (194):
With reference again to FIG. 13, at block 320 a test is made to determine if the user wishes to save a transitional or morphed view of an image. If a transitional view is to be saved, the user may establish the percentage transition, i.e., anywhere from zero to 100 percent transition (zero percent being the original image and 100 percent being the edited image), by floating the pen up or down above the tablet to establish the view, and the pressing the tip of the pen against the tablet to freeze the transitional image, as indicated in block 322. If the tip is pressed again, the frozen image is saved. The save options are available with or without the priority areas in effect. After the save has been accomplished, or if the user did

not wish to save a transitional view of an image, the Compare option is complete and the routine branches to block 326.

Detailed Description Text (195):
In an alternative embodiment of the invention, the Compare option allows a user to compare a modified image with any edits made to the modified image during the current editing session, i.e., before the changes are permanently saved to the modified image. Specifically, with reference to FIG. 2, this embodiment of the Compare option contrasts the image in the current image buffer 54 with the image in the modified image buffer 52. As discussed above, this embodiment of the Compare option may also be used in conjunction with the Prioritize option to allow the user to select priority areas for comparison. In this case, the priority areas transition from the modified to the current image, while the modified image only is displayed in the other (nonselected areas) areas.

Detailed Description Text (196):
At block 326, a test is made to determine whether the user wishes to view a split image. The Split Image option is used on a frontal picture only, and allows a patient to see his or her asymmetries. If a split image view is desired, the user is prompted to select an image, e.g., original or modified, at block 330. At block 332, a vertical centerline is displayed on top of the selected image. The user is then prompted to position the centerline at the location desired, as indicated at block 334. Typically, the centerline will be positioned to dissect the image into equal halves, using the nose and the eyes as reference points. At block 336, the aesthetic imaging system displays two images, one showing the left halves pieced together and the other the right halves pieced together. Specifically, the aesthetic imaging system will produce an inverse image of the left (right) half and then add it to the left (right) half

Detailed Description Text (197):
FIGS. 15A-15C illustrate the resultant images that are displayed when the Split Image option is invoked. In FIG. 15A, a frontal image 350 of a patient is shown, including a centerline 352 that has been positioned at the center of the patient by a user. FIG. 15B is an illustration of the left halves of the image after being pieced together by the aesthetic imaging system, as indicated by reference numeral 354. FIG. 15C is an illustration of the right halves of the image, as indicated by reference numeral 356. With the Split Image option, patients can view what they would look like if their faces were symmetrical. The tool is especially useful in the consultation stage because many people do not realize that the typical face is asymmetrical, and changing a face to be perfectly symmetrical, if possible, is not necessarily desirable.

Detailed Description Text (198):
Once the split images have been displayed, or if the Split Image option was not selected, a test is made at block 360 to determine if the user wishes to view an inverse or mirror image of a picture, e.g., to show patients the view they see of themselves when looking into a mirror. If an inverse image is desired, the user is prompted to select an image to be viewed at block 362. The selected image is then "flipped" using the aesthetic imaging system, and displayed on the monitor, as shown at block 364. After the image has been displayed, or if the inverse image option was not invoked, routine returns to block 86 of FIG. 3.

Detailed Description Text (199):
When viewing an image on the monitor, it is important that a patient remains focused on the image being manipulated rather than on the features of the aesthetic imaging system. When certain viewing options are selected, for example, the prioritize option shown in FIGS. 14A-14D, or the split image option shown in FIGS. 15A-15C, the menu bar normally located across the top of the display is therefore removed. Only the image of the patient is kept on the screen, ensuring that the patient remains focused on the image being manipulated.

Detailed Description Text (200):
In certain situations where it is necessary to display a menu bar, however, it is advantageous to minimize the visual appearance of the menu bar. FIG. 20 is a representative image 410 of a patient with a menu bar 412 located across the top of the screen 414. To reduce the distraction caused by the menu bar, the menu bar is preferably translucent to allow the user to view the patient's image through the menu bar. The text 416 and the line 418 indicative of the menu bar are preferably presented in a contrasting, yet muted, color to allow the user to read the commands.

For example, the text and the line outlining the menu bar may be presented in an off-white. While editing the image with a patient present, the patient is therefore not overly distracted when the menu bar periodically appears at the top of the screen. Even when the menu bar is present for extended periods of time, a patient is not distracted since it does not visually stand-out from the patient's image. At the same time, a skilled user is provided with sufficient information about the menu choices to allow them to choose the appropriate menu options.

Detailed Description Text (202):
FIG. 21 is a flow chart of an exemplary routine for implementing a zoom feature in the aesthetic imaging program. The zoom feature allows a user to increase the scale of the image to better view a selected area and to improve the ability of the user to edit fine details in the image. At a block 400, a zoom point is selected by a user. The zoom point identifies the center of the image to be expanded under the control of the user. At a block 402, the picture is adjusted to position the zoom point at the center of the monitor. Centering the picture ensures that as the image is enlarged, the portion of the image surrounding the zoom point will be displayed. At a block 404, the user is allowed to input a desired magnification factor. Preferably, the magnification factor is selected by floating the pen from the bottom (minimum magnification) to the top (maximum magnification) of the tablet. As the user floats the pen over the tablet, the image on the monitor is correspondingly magnified and redisplayed at a block 406. With each redisplay of the image, at a block 408 a test is made to see if the user has frozen the image by pressing or tipping the pen. Once the image is frozen at a desired magnification, a user can manipulate the image using the array of drawing tools described above. It will be appreciated that for very fine work, such as removing small wrinkles surrounding a patient's eyes, the ability to magnify the image increases the quality of the editing that may be achieved.

Detailed Description Text (203):
Several refinements of the zoom feature may be incorporated in the aesthetic imaging program to improve the results of the zoom. For example, a smoothing function may be incorporated in the zoom feature to ensure that as the image is magnified it does not become "pixelly" or grainy. The smoothing function may be implemented in software. Preferably, however, the smoothing function is implemented in hardware, such as a smoothing feature provided in the Targa 2000 board described above and incorporated in the aesthetic imaging system. Further, feedback may be provided to the user in the form of a numerical display on the image to indicate the approximate magnification as the user floats the pen from the bottom to the top of the tablet. Other means can also be implemented to allow the user to select the desired magnification, including a pull-down menu or numerical entry.

Detailed Description Text (204):
Yet another view option provided to the user in the aesthetic imaging system is an Emboss option. It has been found that the emboss viewing option is very helpful in allowing a user to discern wrinkles or other skin imperfections in a displayed image. By selecting the emboss option, the user causes an image of the patient to be displayed in a gray scale. The emboss option displays an image that is similar to an etching made of a three-dimensional raised surface. A two dimensional image is portrayed, with the depth of the raised surface indicated by a darker shade of gray. The emboss option removes any deceptive information conveyed by the color or shading of the skin of the patient and allows any raised or depressed areas to be clearly highlighted. When viewing wrinkles or other imperfections on a patient, the emboss option therefore clearly identifies the raised or depressed features over the smooth skin of the patient.

Detailed Description Text (207):
dx and dy =the offset of the emboss operation; and

Detailed Description Text (209):
After selecting the emboss option, the user may manipulate the offset of the emboss by floating the pen over the tablet. Floating the pen parallel to the x-axis of the tablet adjusts the dx parameter in the emboss function, and floating the pen parallel to the y-axis adjusts the dy parameter in the emboss function. It has been found that various features on the skin of a patient can be brought into greater clarity by adjusting the offsets of the embossed image. A user may therefore focus on the desired feature that they wish to show a patient. When the desired offsets are selected, the user may freeze the offsets by tipping the pen on the tablet. A user may then adjust the scale parameter by floating the pen parallel to the x-axis

of the tablet. Again, it has been found that various skin features can be brought into greater clarity by adjusting the pressure of the emboss. When the desired pressure results are achieved, the user may freeze the image by tipping the pen on the tablet.

Detailed Description Paragraph Table (1):

Copy, Cutout, Resize	Stretch, Rotate
Freeze Compare	
Zoom	Zoom
Undo	Undo
Compare	Compare
Split image	Split image
Split Image	Inverse
Inverse	Blend
Blend	

CLAIMS:

1. A user interface for an aesthetic imaging system containing digitized images of a patient, the aesthetic imaging system allowing a user to manipulate a patient image to display potential results achievable through cosmetic surgery, the aesthetic imaging system including a processor, a memory, a monitor, and means for controlling a cursor displayed on the monitor, the user interface comprising:

(a) a display area for displaying a digital image of a patient comprised of a plurality of color pixels; and

(b) a command menu area for displaying a plurality of commands that may be used to manipulate the digital image of the patient, the command menu area substantially overlapping the display area so that a portion of the digital image is positioned behind the command menu area, the command menu area being substantially transparent to allow the portion of the digital image positioned behind the command menu area to be visually apparent to a user, the plurality of commands in the command menu being substantially opaque and visually distinguishable from the portion of the digital image positioned behind the command menu area to allow the user to select from the plurality of commands.

3. The user interface of claim 2, wherein the plurality of commands in the command menu area are removed during editing of the digital image.

L27: Entry 2 of 3 File: USPT Mar 4, 2003

DOCUMENT-IDENTIFIER: US 6529617 B1
TITLE: Method and apparatus for positioning an instrument relative to a patients body during a medical procedure

Abstract Text (1):
A method and apparatus for annotation of medical imagery to facilitate patient identification, diagnosis, and treatment is characterized by an imaging device for producing a first signal representative of sensed characteristics of the individual and a minutiae generator which receives the first signal and produces a second signal representative of minutiae of the individual, the minutiae corresponding to specific branch points of blood vessels of the individual. A minutiae data generator analyzes the characteristics of minutiae and produces a third signal representative of the characteristics which is stored in a minutiae database for each of the plurality of known individuals and their medical conditions. The minutiae and minutiae data may be used to annotate medical imagery to facilitate subsequent image comparison by providing standardized registration points and time-varying characteristics. A minutiae matcher pairs corresponding second signals and third signals from a current patient with those from a database record, and the paired signals are used to align the images and compare them. The minutiae analysis techniques of the invention can be used to identify medical patients, assist in the diagnosis of medical conditions, and detect and monitor the use of alcohol and drugs, including anesthesia.

Brief Summary Text (2):
This invention relates generally to the field of image recognition and processing and specifically to methods and systems for identifying, diagnosing, and treating people based on thermal minutiae within a person's body, primarily the face.

Brief Summary Text (10):
Inkless techniques are now generally used to produce a "tenprint" card which substitutes for the former rolled print card. Common inkless techniques utilize polarized light to illuminate the fingers, and light sensors to image the light reflected and refracted from the ridges. The resulting image can be more consistent and higher quality than the rolled prints, since inconsistencies in the amount of ink applied and in the pressure used to transfer the print to paper are not a factor.

Brief Summary Text (19):
A known algorithm of the National Institute for Standard Technology can be used to compare a previously stored electronic image of minutiae coordinate locations with the minutiae locations identified and stored by the computer.

Brief Summary Text (20):
U.S. Pat. No. 5,040,224 to Hara discloses a fingerprint processing system capable of detecting a core of a fingerprint image by statistically processing parameters. Hara's invention provides a system to determine a core in the fingerprint image and/or to detect directions and curvatures of ridges of the fingerprint image prior to detection of the position of the core. This reference defines minutiae as abrupt endings, bifurcations, and branches.

Brief Summary Text (21):
U.S. Pat. No. 4,790,564 to Larcher teaches a process and apparatus for matching fingerprints based upon comparing the minutiae of each print in a database with precomputed vector images of search minutiae in a search print to be identified, comparing position and angle, a result of such comparison being a matching score

indicating the probability of a match between the angle of a file print minutiae and the angle of precomputed vector images of the search minutiae. Over an under-inking of a rolled print can change the apparent type of minutiae associated with a particular point from one printing to the next. However, not all corresponding minutiae will appear to change type in the two pairs. Therefore, matching for type as well as for x and y coordinates provides a stricter match requirement and results in better system accuracy. Larcher assigns higher values to minutiae which match in x,y and type.

Brief Summary Text (22):
As Larcher points out, there are advantages to matching minutiae rather than the entire image of the fingerprint in itself. An elementary matching operation comprises the comparison of two sets of minutiae, i.e., two sets of points, each point having three coordinates x, y, and a. An elementary matcher attempts to superimpose the two sets of points, in order to count the number of minutiae which are common to the two fingerprints.

Brief Summary Text (27):
Other known approaches compare two sets of image features points to determine if they are from two similar objects as disclosed for example in Sclaroff and Pentland, MIT Media Laboratory, Perceptual Computing Technical Report #304. This reference suggests that first a body-centered coordinate frame be determined for each object, and then an attempt be made to match up the feature points.

Brief Summary Text (31):
Second, the image is divided into pixels, where the size of the pixel relates to the quality of the result desired;

Brief Summary Text (33):
Fourth, each minutia is assigned a vector having magnitude and directional information in relation to the surrounding characteristics of the fingerprint. Typically for each fingerprint, there would be a substantial number of minutia vectors characterizing its image;

Brief Summary Text (39):
Still another known scheme utilizes eigenanalysis of visual face images to develop a set of characteristic features. Pentland, View-Based and Modular Eigenspaces for Face Recognition, MIT Media Laboratory Perceptual Computing Section, Technical Report No. 245. Faces are then described in terms of weighting on those features. The approach claims to accommodate head position changes and the wearing of glasses, as well as changes in facial expressions. This disclosure teaches that pre-processing for registration is essential to eigenvector recognition systems. The processing required to establish the eigenvector set is extensive, especially for large databases. Addition of new faces to the database requires the re-running of the eigenanalysis. Accordingly, use of eigenanalysis may not be appropriate for use in a general face identification system such as would be analogous to the FBI's and AFIS fingerprint system.

Brief Summary Text (42):
One known scheme using facial thermograms for identification is described in the Prokoski et al U.S. Pat. No. 5,163,094 which discloses defining "elemental shapes" in the surface thermal image produced by the underlying vascular structure of blood vessels beneath the skin. Depending on the environment of use, thermal facial identification may provide greater security over identification from visual images and may therefore be considered preferable. It is extremely difficult, if not impossible, to counterfeit or forge one face to look like another in infrared, whereas it is often possible to disguise one person to look like another in visible light. However, the use of elemental shapes is found in practice to be vulnerable to such variables as head rotation and tilt, ambient and physiological temperature changes, variations in imaging and processing systems, and distortions or obstructions in a facial image (e.g., due to eyeglasses).

Brief Summary Text (43):
Eigenanalysis of the elemental shapes of a thermal facial image has also been used for recognition. In one approach, several sets of elemental shapes are produced for each image by imposing different thermal banding constraints. The totality of shapes are then analyzed with respect to a library of facial thermal images. Eigenshape analysis is used to compare the characteristics of shapes in each person's images. Eleven characteristics of each shape are considered, including: perimeter, area,

centroid x and y locations, minimum and maximum chord length through the centroid, standard deviation of that length, minimum and maximum chord length between perimeter points, standard deviation of that length, and area/perimeter.

Brief Summary Text (44):
Each person's image is then characterized by set of 11-coefficient vectors. The difference in eigenspace between any two images is calculated to yield a measurement to which a threshold was applied to make a "match/no match" decision. In practice, such a system yields a useful method and apparatus for some applications. However, the calculation techniques for such a system are computationally intensive and require additional computational analysis of the entire database when new images are added. As with others of the prior known techniques, recognition is seriously impacted by edge effects due to head rotation and tilt, and by loss of definition in very cold or very hot faces.

Brief Summary Text (46):
Therefore, the need remains for a system and method that can be used to reliably recognize and verify the identity of an imaged person without manual assistance and without cooperation from the person being identified.

Drawing Description Text (11):
FIG. 8 is a block diagram of the apparatus for annotating an image of the human body according to the invention;

Drawing Description Text (12):
FIG. 9 is a block diagram of a modified apparatus of FIG. 8 for identifying reference minutiae in an annotated image;

Drawing Description Text (13):
FIGS. 10a, 10b, and 10c illustrate facial minutiae superimposed on three different thermal images, respectively, of the same face;

Drawing Description Text (14):
FIG. 11 is a block diagram of an apparatus for annotating a medical image of the human body according to the invention;

Detailed Description Text (4):
In operation, thermal imaging device 102 obtains a thermal image of the face of person 101. A digital signal representative of the thermal image is provided as input to minutiae generator 104, which generates signals representative of thermal facial minutiae points for 101. These minutiae points have a number of characteristics including a specific location within the person or relative to other minutia, the apparent temperature at a given time, the temperature signature over a period of time, whether the minutia corresponds to a vein or artery, the width of the blood vessel, and the vector direction of branching blood vessels from the minutia. These and other characteristics are sensed and data relative thereto are generated by a minutia data generator 105. This data is stored in the minutiae database 111. The minutiae matcher 106 compares minutiae data for known individuals which has been stored in the database with that for unknown individuals currently being imaged by the imaging device 102. If a match is detected, a corresponding signal is sent to the output display/processing device 114.

Detailed Description Text (7):
Thermal imaging device 102 may be any device that produces a signal representative of the thermal characteristics of the face portion 101. In a preferred embodiment, a conventional digital video camera sensitive to thermal energy is used for the thermal imaging device 102. As described herein, it is found that tractable imagery for facial identification may be derived from passively obtained infrared images of facial heat emanations which can be detected by commercially available thermal imaging devices sensitive in the 3 to 12 micron wavelength band. Unlike fingerprints that are characterized by a limited range of intensity values corresponding to three dimensional ridges which are essentially concentric rings about a single center, plus anomalous arches, line endings, and bifurcations, facial thermograms are generally characterized by continuously varying wide distribution of temperatures, including multiple maxima and minima values. Where the skin surface is unbroken, there is gradual variation of temperatures from the hot areas on either side of the nose to the relatively cool areas of the ears and checks. The eyes appear to be cooler than the rest of the face. The nostrils and mouth, and surrounding areas, will look warm or cool depending upon whether the subject is inhaling or exhaling

through them. Discontinuities in the skin surface temperature may be evident where scars, moles, burns, and areas of infection are found.

Detailed Description Text (8):
In some applications, thermal imaging device 102 may be adapted for attended operation using cooperative persons 101 and a human supervisor, as with identification systems based on rolled fingerprints. In these applications, the supervisor can ensure that person 101 is properly positioned, and can adjust gain, focus, and other parameter of thermal imaging device 102 to optimize the quality of the thermal image produced by thermal imaging device 102. In other applications, thermal imaging device 102 is adapted for unattended, stand-alone operation, for instance with live scans used for access control to a remote secure facility. System 100 can further be configured based on an expectation that person 100 will be either cooperative (e.g., moving to a specific requested location for optimal imaging) or uncooperative (e.g., a mere passer-by). In environments where uncooperative persons are expected, identification will be facilitated by collecting the maximum possible amount of data, for instance by using multiple thermal imaging devices 102 and fast frame (i.e., sampling) rates. Additional related data, referred to herein as "ground truth" data, may be collected as well to provide information on factors such as ambient temperature, absolute size of the imaged face, or the distance of the imaged face from thermal imaging device 102.

Detailed Description Text (11):
Various perturbations, such as facial expression changes, can distort the relative locations of minutiae points. This is an analogous to the deformations that occur in fingerprints due to movement or pressure between the fingers and the print surface. As described below, minutiae matcher 106 allows for some variations in the position and characteristics of the minutiae, as well as in the subset of minutiae which are seen due to the field of view of thermal imaging device 102 and to possible obstruction of certain areas of the face in the image.

Detailed Description Text (18):
In a preferred embodiment, minutiae generator 104 locates the left canthi area and the right canthi area and determines the centroid for each area. The location of the centroid is essentially independent of the grey scale allocation of the analog thermal image produced by the camera 102. The centroids are referred to as left and right canthi 201, 202 herein.

Detailed Description Text (20):
Other techniques may be used for location of the face center point 209 in those cases where the preferred use of facial symmetry and recognizable thermal features does not suffice. For example, other techniques may be called for with respect to facial images in which an eye patch is worn, eyeglasses are not symmetrical, only a partial face is imaged, the lower face is covered, or the thermal pattern of the face is unusually distorted. The face center point 209 may in fact be outside of the boundaries of the facial image, for instance where only a partial facial image is obtained due to the face being partially blocked by another face or some other object. If the person 101 is wearing glasses, the pattern of the glasses, which typically block the infrared emissions from the face and thereby produce an extended cold area with sharp thermal discontinuity, can be used to determine approximate face axes. Additional techniques include manual location of the face center point 209 and preprocessing using known techniques to locate the approximate area of the face center point 209. As described below, the face axes may be tested for validity to determine whether the image requires any such special treatment.

Detailed Description Text (22):
Since the known techniques for identifying left and right canthi centroids 201, 202, left and right nostrils 203, 204, and mouth area 205 are subject to artifacts and other sources of error, and since some images of faces are significantly asymmetric or have features that are entirely missing (e.g., due to person 101 wearing an eye patch or having a disfigured face), minutiae generator 104 performs checks to help spot instances where these points may have been incorrectly located or where unusual facial images are encountered. First, a check is made to ensure that vertical central line 208 and mouth line 207 intersect within mouth area 205. Next, a check is made to ensure that vertical central line 208 intersects a line connecting left and right nostrils 203, 204 at point between left nostril 203 and right nostril 204. If either of these conditions is not met, the face is considered to be a special case calling for manual intervention to determine the best approximation for face axes.

Detailed Description Text (24):
In practice, it is found that preprocessing through normalization of image size provides advantages in later recognition. Accordingly, minutiae generator 104 uses the distances between left and right canthi centroids 201 and 202 and the distance from face center 109 to eye line 206 to compare the size of facial thermogram 200 with a standard image size. In a preferred embodiment, linear correction in the vertical and horizontal dimensions is used to normalize the size of facial thermogram 200 to match the standard, but other normalization models could be used as well.

Detailed Description Text (26):
As provided by thermal imaging device 102, facial thermogram 200 consists only of an ordered list of thermal values corresponding to each small portion of the imaged face. Minutiae generator 104 employs the following procedure to produce thermal contour lines for facial thermogram 200. a. For a digitized image having N bits of resolution, or 2.sup.N bands of thermal values, determine thermal contour lines having a particular "current" one of the 2.sup.N values. b. Produce minutiae in accordance with the steps below for the contour lines of the current value. c. Repeat a and b above, each time using new one of the 2.sup.N values for the "current" value, until the desired number of minutiae have been extracted of all of the possible values have been processed. d. If the desired number of minutiae have not been extracted, repeat the process beginning with 2.sup.N-1 bands of values, and reduce the number of bands by 1 with each iteration, skipping those that are powers of 2, until the desired number of minutiae have been extracted or until no further reduction in bands can be achieved.

Detailed Description Text (29):
In a preferred embodiment, points on a thermal contour are considered minutiae if they form inflection points for the contour. However, to avoid artifacts resulting in too many minutiae being selected, only inflection points for curves below a threshold radius will be considered minutiae. Therefore, minutiae generator 104 selects a maximum radius of curvature to be used in determining minutiae, based on characteristics of system 100 such as the resolution of thermal imaging device 102, the lens used, the quality of the recording and processing system, the desired number of minutiae to be extracted, the desired sensitivity and vulnerability of the system to minor variations in thermal image, the accuracy of the three dimensional model for registration of the face image, and the magnitude of systematic and random errors.

Detailed Description Text (32):
Minutiae generator 104 selects minutiae from the facial thermogram 200 after preprocessing as described above by first positioning a circle of radius R on a thermal contour such that the contour intersects the circle, crossing it at two points and dividing it with equal area in each half. Next, this circle is moved along the contour for as far as the contour can continue to intersect the circle at exactly two points while maintaining an equal area on either side. If, in so moving the contour, a location is found where further movement would cause the contour to intersect the circle at only one point, the contour has ended, and the end point is designated as minutia point. This situation typically occurs only at the edge of a facial image and only rarely within the area of the face. If a location is found where further movement would cause the contour to intersect the circle at three or more points, there is an inflection point within the circle. It can be located by considering the slope of the contour within the circle relative to the face axes. The point of maximum change in slope is then designated as a minutia point. If a location is found where further movement would cause the contour to intersect the circle at no points, there is a small island area within the circle. The centroid of that island is designated a minutia point.

Detailed Description Text (33):
Referring now to FIG. 5, there is shown a facial image on which minutia points, e.g, 301, have been identified on facial thermogram 200, as described above.

Detailed Description Text (37):
As another possibility, only centroids located near the center of the face, or in concave areas of the face less vulnerable to artifacts due to edges, could be used. In other applications, minutiae may be derived using centroids of images where all thermal values less than a threshold are maintained, but those higher values are collapsed in one band. Centroids may be added to the set as the threshold is

reduced. In such instance, each minutia point is characterized using at least the (x, y, z, T) factors mentioned above, where T is the threshold. In a variation on this minutiae generation technique, inflection points produced from such thresholding rather than the centroids may be used.

Detailed Description Text (39):
An additional approach is to designate undefined locations generated by compression and subsequent expansion of the image. Specifically, facial thermogram 200 is compressed using wavelet of fractal-based methods and then expanded again. Because such compression techniques are lossy in a deterministic way, a minutia set may be defined as the undefined locations resulting from a comparison of the original image with the compressed-and-expanded image. This approaching provides an additional advantage of compressing the data used for recognition.

Detailed Description Text (41):
As mentioned above, it may be desirable that all thermal images be scaled to a standard size prior to processing. It also may be desirable, depending on the thermal imaging system used, that all thermal images first be normalized to a standard thermal profile before processing. In alternate embodiments, intended for various applications and various environments, these preprocessing steps may significantly increase accuracy in recognition or may merely impose unnecessary processing overhead. For example, if system 100 is used in connection with an outdoor automated teller machine, thermal normalization may be needed to deal with seasonally wide variations in surface skin temperature.

Detailed Description Text (43):
As mentioned above, minutiae generator 104 and minutiae data generator 105 are used to produce minutiae data signals for a population of known persons. The data corresponding to these signals are stored in minutiae database 112. Thermal imaging device 102 then obtains a thermal image of an unknown person 101 and minutiae generator 104 produces signals representative of the minutiae and minutiae data generator 105 generates data for the minutia for that person. Once these signals have been produced, minutiae matcher 106 compares the signals representative of person 101 to signals from minutiae database 102 corresponding to minutiae data of known persons. In a preferred embodiment, minutiae matcher 106 performs three basic functions to obtain a match: alignment of the unknown face, comparison of minutiae data, and selection of a match. Each of these functions is described in greater detail below.

Detailed Description Text (45):
Because there may not be control over the position of the face of person 101 with respect to the field of view of thermal imaging device 102 when image is obtained, the orientation of the face may not be such that the facial axes are aligned to be horizontal and vertical. Thus, minutiae matcher 106 corrects the orientation by rotating the image such that the facial axes are horizontal and vertical. Next, conventional processing using a three dimensional model is applied to correct for any rotation or twist of the head. In a preferred embodiment, such processing models the head as a sphere with a diameter equal to the apparent width of the face, and anti-distorts the image to provide a view which is normal to a surface plane across the forehead and upper lip and in which the enter of the sphere conincides with the face center. In a conventional manner, the nose and chin are ignored so as not to disrupt positioning of this surface plane.

Detailed Description Text (47):
Comparison of the minutiae data of the unknown person 101 with minutiae data from known persons begins by comparing locations of such minutiae. First, the locations of minutiae for a known face are considered, and denoted as M(K)i. Next and allowed positional error .epsilon. of one of the M(K)i are ignored. Any M(K)i which are not within .epsilon. of on the M(U)j are ignored. This leaves a residual set of minutiae pairs. If this set is empty, there is not a match between the two images. Otherwise, the characteristics of the corresponding points are compared.

Detailed Description Text (52):
Further levels of decision requirements can similarly be added to produce the desired level of confidence in the match for the application at hand. Each possible comparison of the unknown face with known faces is performed, and then the known images are rank-ordered according to the goodness to fit (e.g., closeness in metric) with the unknown face.

Detailed Description Text (54):
Through experience with use of the system on new images of known persons, a threshold value is established to provide a desired ratio of false positive and false negative identifications appropriate to the particular application. In a preferred embodiment, both self-correlations of multiple images of known persons and cross-correlations of different known persons in the database are used to help establish this threshold.

Detailed Description Text (55):
If only one known person meets the threshold requirement, that person is selected as the match. If no known person meet the threshold requirement, a failure to match signal is produced. If multiple known persons match the unknown person to within the threshold difference, the best matching person is selected. Alternatively, if multiple images of the same known person are referenced in minutiae database 112, the person having the highest ratio of matches within the top number of best matches may be used. For instance, if there are ten images of each known person in database 112, the top ten matching images determined by minutiae comparison are considered. The person who is associated with the most of the top ten is selected to be the matching person. Additional levels of decision requirements may be added, either in a simple manner or iteratively, with a determination after each level as to whether a match decision can yet be made.

Detailed Description Text (56):
In an alternative embodiment, minutiae matching is performed using techniques disclosed in U.S. patent application Ser. No. 07/984,514, filed Dec. 2, 1992, and U.S. Pat. No. 08/314,729, filed Sep. 29, 1994, which is a continuation of U.S. patent application Ser. No. 07/984,514, both of which are hereby incorporated by reference in this application as if the entire contents of each had been fully reproduced herein. In this alternative embodiment, flash correlation is used to match minutiae through a digitized artifact-producing technique. In this embodiment, the size of a minutia point is preferably increased to represent the possible error in its location, and minutiae are replicated successively along the face axes to increase their density and thereby increase the discernability of the correlation artifact that indicates a match between two images being compared. Such artifact is found to occur if any only if there is a match between two pixelized images.

Detailed Description Text (57):
Other known matching techniques may alternatively be used in minutiae matcher 106, with tolerances established for errors due to imperfect knowledge of head position or distance, errors introduced by considering the head or face as a two dimensional surface or as a sphere, and other systematic and random residual errors. Some known fingerprint matching techniques may also be adapted to use with minutiae matcher 106. By analogizing thermal contour to fingerprint ridges, the multiplicity of facial thermal contours may be treated in a manner similar to matching many fingers per person. Alternatively, specific areas of the face, such as surrounding the canthi, may be selected and used alone for identification. Depending on the resolution of the thermal imaging device 102, several hundred minutiae may be extracted from a facial thermal image. As noted above, lack of prior knowledge of which facial features, and which specific matching techniques are used for any particular application by system 100 increases the security of system 100 against being compromised by third parties.

Detailed Description Text (59):
Another approach to classification of facial thermograms relates to obvious characteristics for use in verbally describing a given facial thermogram. Such characteristics include whether the canthi are merged or separated; whether the thermal contour of the nose is relatively cold, hot, or normal; whether the nose is trapezoidal in shape or irregular in shape; the degree of thermal symmetry of the forehead; and the degree of symmetry in location of thermal features in the mouth corners, the inner curves of the cheeks, the nose, the canthi, and the outer corners of the eyes. To be useful, such designations should remain consistent over variations in imaging equipment, environmental conditions, physiological variables, and other sources of errors. Accordingly, classification should not rely on features determined to be highly sensitive to such factors. Classifications based on overall image, e.g., those based on some of the distances between the features discussed in connection with FIG. 4 may be suitable for use.

Detailed Description Text (60):
Another approach is to use wavelet coefficients that produce the minimum difference

between an interpolated wavelet-compressed image and the original image. Depending on how many classes are desired, that number of wavelet coefficient sets can be generated. Each image to be classified is compressed and then restored using each of the sets. The image is assigned to the class corresponding to the set of wavelet coefficients which best restores the image to its original form.

Detailed Description Text (64):
The usefulness of facial thermal imaging in recognition applications is increased by appropriately encoding thermal facial images so that consistent codes are generated each time a facial thermogram of a person is obtained. Such a coding scheme reduces database search and minutiae matching overhead, thereby allowing faster processing using less expensive equipment. In a preferred embodiment, overlaying a grid on a face such that 144 cells cover the area of the face, and assigning a binary code to each cell, such t hat the cell is encoded with a "1" if the cell contains one or more minutiae and "0" if the cell does not contain any minutiae, is found in practice to yield good results. Since this encoding scheme preserves the relative location of each bit, it is straightforward to ignore selected bits in cases where only a portion of a face is imaged, due to obstruction, disguise, or orientation.

Detailed Description Text (66):
Although the discussion above has been directed to thermal images of faces, it should be recognized that similar techniques and systems may readily be applied to images of other body parts in accordance with the present invention. It should also be recognized that numerous other imaging modalities besides thermal imaging may be employed in accordance with the present invention, for example x-ray, NMR, MRI, and CAT scan imaging. It should also be recognized that known schemes for pattern recognition and graph matching may be applied readily in accordance with the present invention, depending on the needs of a particular application.

Detailed Description Text (68):
The method and apparatus described above for facial minutiae extraction can be used to develop a standardized minutiae co-ordinate system for identification of medical patients and for diagnosis of medical conditions. Because an infrared camera operates at a distance from the patient and detects and records only radiant heat spontaneously emitted from the body surface, it constitutes a painless, non-invasive, passive method of recording patterns of body surface temperatures. These patterns have been found to depend upon the underlying vascular structure and are unique for each person. Infrared identification therefore provides a method for uniquely identifying individuals under all lighting conditions, including total darkness. It is not prone to forgery or multiple identity deception and so provides convenient and highly secure identification of individuals. The method for generating repeatable registration points on the skin surface of the human body utilizes discrete minutiae points obtained from the thermal images. Visual characteristics of the body, such as size and shape and relative position of body parts, are maintained in the infrared image. In addition, the details of the vascular system are indicated by the distribution of temperature cross the skin surface. Current infrared cameras are sufficiently sensitive to temperature variations that they clearly distinguish the skin directly overlaying blood vessels due to the thermal difference caused by the flow of warm blood. The vascular structure appears as a white (hot) overlay of the circulatory structure on top of a grey scale image of the thermal map of the body, as shown in FIG. 7.

Detailed Description Text (69):
In FIG. 8, there is shown apparatus 100a for processing infrared images to yield repeatable minutiae points corresponding to specific vascular locations under the skin. The apparatus includes a thermal imaging device 102 for producing a thermal image I. A minutiae generator 104 and minutia data generator 105 are part of the program memory 108 as is a minutiae overlay device 116. The set of minutiae obtained from any extended are of the body is unique to each individual. In particular, facial minutiae are unique between identical twins. The same thermal minutiae are repeatedly extracted from a given individual. They are overlaid by the overlay device 116 and annotated by an image processor 118 on the infrared image or on a visual or any image obtained from another medical sensor having the same orientation to the subject. From the processor, the annotated image signal is delivered to an output display/processing device which produces the thermal image with overlay IO.

Detailed Description Text (70):
In FIG. 9, there is shown a modified apparatus 100b to that of FIG. 8, wherein a reference minutiae identifier 120 is provided between the minutiae data generator

105 and the minutiae overlay device 116 to identify and specify reference points 151 in the thermal image and overlay IO. The reference points allow manual or automated comparison, merging, or registration among a set of images taken at different times with different orientations or different medical instruments. FIGS. 10a-c illustrate minutiae automatically extracted from a facial thermogram as the head turns. Current infrared cameras commonly produce 30 frames of video output per second, and minutiae extraction and annotation can be performed in real time as those frames are generated.

Detailed Description Text (71):
FIG. 11 illustrates alternate apparatus 100c for generating a medical image MI of a portion of the body via a medical imaging device 122 such as an x-ray machine. The medical image can be annotated with a minutiae overlay to generate a medical image with minutiae overlay MIO from the output display/processing device.

Detailed Description Text (72):
The inventive technique differs from visible recognition approaches in that it does not merely sample a finite number of points on an image; it extracts points which have particular meaning. This provides increased resolution at the same time it reduces the degree of computation required. The essential features of the technique are the uniqueness and invariance of thermograms, the use of a passive imaging technique to obtain subsurface details, the use of automated minutiae extraction to match different images taken of the same individual, and the use of standardized minutiae locations to compare different persons or the same person as he grows from childhood to adulthood. The matching technique involves developing sets of corresponding points in two images, morphing one image into the reference, and measuring the degree of morphing as an indicator of the amount of difference. Similar automated procedures are then used to verify that imagery is from the same patient, identify a patient by comparison to a database of images, and compare images taken at different time and/or with different sensor modalities.

Detailed Description Text (75):
Verification that two medical images are from the same person can be an end goal in itself or the first step in further processing the two images to extract comparison data. Telemedicine applications, electronic filing systems, insurance claims processing, updating of medical records, and extraction of medical histories during emergency treatment are some of the situations in which it is essential to have a reliable, fool-proof method for positive identification of the subject and precise localization of imaged areas.

Detailed Description Text (76):
The use of infrared identification (IRID) has several advantages over other methods for recognition of persons. IRID operates regardless of lighting conditions. It requires only a single frame of imagery, taken in 1/30 of a second, for positive identification, and so can provide on-the-fly recognition during emergency admissions or evacuations. This imagery can be collected at a distance, without causing a delay or inconvenience to the subject. No parts of the system come into contact with the subject. Since thermal images are essentially immune from variations caused by illumination and shadows, it is not necessary to control those variables. IRID provides continuous identification and confirmation verification of ID even in the dark. A cheaper, cruder form of thermal imaging can be obtained from use of heat-sensitive crystal sheets, which require contact with the skin. More expensive, active imaging of the vascular system can be obtained from laser doppler. Either of these could be the source imager for extractions of minutiae; however, the operational advantages of passive thermal imagers make them the preferred sensor.

Detailed Description Text (77):
Thermal minutiae can be obtained from commercially-available thermal imaging devices sensitive in the 3 to 5 or 8 to 12 micron wavelength bands. Images are this type are shown in FIGS. 7, 10, 12, and 13.

Detailed Description Text (78):
Current infrared cameras produce a standard analog or digital output providing 30 frames per minute as shown in FIGS. 7-10. Tracking the minutiae from frame to frame assists in the exploitation of the dynamic IR imagery by allowing measurements to be made over time from the same body locations while accommodating changes in position due to respiration, voluntary or involuntary movements of the subject, and intentional or accidental variation in the position of the imaging system. The use of infrared video imagery also allows the imagery to be recorded in real time for

later analysis, and provides a self-documenting chain of custody identification of the person recorded, all without the necessity for the cooperation of the person being imaged.

Detailed Description Text (79):
Infrared imaging can be used to locate minutiae points over the entire body surface which correspond to intersection points and branch points of the underlaying blood vessels. This provides a built-in set of registration points on the body's surface, which can be annotated onto images produced by any medical sensor used in conjunction with the thermal imager. The registration points then can be used to compare and combine medical images taken with different equipment at different times and under different conditions, facilitating comparison of those images. Also, the minutiae points provide reference points for continuous re-alignment of surgical instruments, radiation sources, and other diagnostic or treatment equipment. Since the infrared camera is totally passive, it can be used continuously during other medical procedures to overlay precise registration points on the other images while also monitoring for overheating, shock, hyptothermia, renal failure, and other medical conditions. At the same time, the pattern of minutiae points superimposed on each image provides positive identification of the patient. Such applications are of particular importance during telemedicine procedures.

Detailed Description Text (80):
The normal body is basically thermally bilaterally symmetric. Side to side variations are typically less than 0.25 degrees Celsius. This fact is used in assigning axes to the body's image. Where the skin surface is unbroken, there is gradual variation of temperatures across blood vessels, with the highest temperatures across the body surface being directly on top of major blood vessels. Major thermal discontinuities occur at entrances to body cavities such as the eye sockets, nostrils, or mouth. These provide global reference points for automatic orientation of the thermal image. Local and relatively minor discontinuities in the skin surface occur at scars, moles, burns, and areas of infection. The thermal surface can be distorted through pressures and activities such as eating, exercising, wearing the tight hats and other clothing, sinus inflammation, infection, weight gain and loss, and body position. However, the minutiae points remain constant with respect to their position relative to the underlying blood vessels.

Detailed Description Text (81):
The technique for thermal minutiae extraction and matching can be summarized as follows: 1. Current thermal image is digitized. 2. Current image is divided into pixels, where the size of the pixel relates to the resolution of quality of the result desired. 3. Certain pixels are selected as minutiae points. 4. Each minutia is assigned a vector having magnitude and directional information in relation to the surrounding characteristics of the thermal image. Additional characteristics, such as type of minutia may also be recorded for each. Typically for each whole body thermal image, there would be on the order of 1200 minutiae. 5. Set of minutiae vectors of the current image are compared by computer to the set of vectors of other images. 6. Comparison results are used to determine corresponding minutiae from the two images, and to morph or mathematically adjust one image with respect to the other to facilitate comparison. 7. Differences between the current image and database images are computed for either the entire image or for areas of interest.

Detailed Description Text (82):
It is desirable that all thermal images in a database be normalized to a standard thermal range and be scaled to a standard size during search and comparison procedures. Both normalization and scaling eliminate some minute amount of identifying characteristics of a particular person or his condition. However, the standardization procedures greatly aid in the exploitation of the database by reducing the need to calibrate every imaging sensor used to produce images which will be filed in, or compared to database images. For example, in accident triage with no accurate ground truth reference in the scene and possibly use of inferior quality imagers, standardization to constant size and thermal range is appropriate in order to match against database. Furthermore, standardization facilitates use of simulated imagery for telemedicine and telesurgery applications. For example, when incorporated into the military's automated battlefield medical pod, real time normalized thermal minutiae can be used to properly position injections and application of external pressure to stop bleeding.

Detailed Description Text (83):

In addition, standardizing database images facilitates comparison of imagery during growth from childhood to adulthood, compilation of medical libraries of images from large number of people, and automated comparisons of current imagery against the base libraries for diagnostic purposes. Standardization to a common use of thermal minutiae would also provide a common reference for comparing images obtained from different sensors which produce different resolution images.

Detailed Description Text (86):
Blood vessels that carry nutrients to the skin are destroyed when tissue in burned. A high powered laser can be used to remove the burned skin, leaving the healthy skin intact. Laser light is differentially absorbed and reflected by live and dead skin, such as in the area of a burn. Certain dyes such as indocyanine fluoresce when in contact with laser light and can be injected into a patient's blood to indicate healthy tissue. Alternately, an IR imager can be used to indicate dead skin vs. healthy skin, since the dead skin appears relatively cold as a result of having no functioning blood vessels. More than 100,000 person per year in the US alone suffer severe burns. The total cost of treating these patients exceeds $2 billion. Treatment includes massive transfusions to replace the blood lost during surgery to remove dead skin. Blood loss is the main cause of death in burn patients. Continued heavy bleeding often prevents a successful skin graft after the burned skin is removed.

Detailed Description Text (88):
Referring now to FIG. 14, there is shown an apparatus for maintaining the position of a surgical instrument 160 relative to a surgical site in a patient 162 during a surgical procedure. A thermal imaging device 102 such as an infrared camera, generates a thermal image output to a minutiae generator 104 to identify minutiae in the vicinity of the surgical site. As described above with reference to FIG. 9, a reference minutia pattern is also generated for a statutory patient. A surgical instrument position detector 166 senses the position of the instrument and produces an output signal corresponding therewith. The minutiae pattern for the patient and the surgical instrument positions signals are delivered to a comparator 168. The relative position of the instrument to the surgical site is set as a reference at time 0 at 170. Displacement of the patient and/or the instrument with respect to the reference at times other than 0 is detected by the comparator which can produce an output 172 used to reposition the instrument via a device 174 for proper orientation to the surgical site.

Detailed Description Text (92):
Within the next 10 years, both military and civilian medicine are expected to make routine use of telesurgery where the patient and surgeon are not co-located. It is estimated that 90% of the information a physician needs to know about a patient can be acquired and brought to him electronically. In laparoscopic surgery today, a surgeon looks only at video images without looking at the real organs at all. Dermatology and pathology are both already using electronic images as well as x-rays and medical records. Laparoscopic surgery is an electronic form of surgery. Teleradiology, telepathology, and teleconsulation are already widely accepted electronic medical practices.

Detailed Description Text (95):
Many drugs, including cocaine and alcohol, are vasoconstrictive substances which cause cooling of the skin surface, the resultant cooling is detected through passive imaging of the thermal energy emitted form the face. In FIG. 15 is shown the thermal image of an individual who is substance free and in FIG. 16 is a thermal image of the same individual after the ingestion of alcohol.

Detailed Description Text (98):
Variations in temperature across the facial surface can be imaged by thermal cameras sensitive to wavelengths in the 3-5, 8-12, or 2-15 micron ranges. Current cameras can provide thermal resolution better than 0.07.degree. C. and spatial resolution of better than 0.02", resulting in 65,000 to 265,000 discrete thermal measurements across the surface of the face. For most such cameras, that thermal map is generated 30 times per second to produce either a standard video output which can then be recorded and processed on standard videotape equipment, or a direct digital signal which can be immediately input to a computer.

Detailed Description Text (104):
The technology of this patent involves clinical studies in which known amounts of controlled substances are administered to subjects whose thermal images are

monitored and stored to provide archival references. Analysis of those images is used to determine the time-varying thermal effect of specific drugs at specific minutiae sites on the face, which are specified by anatomical landmarks. After an individual ingests a drug, changes in his or her thermal signature gradually occur until a thermal "climax" is reached after which the signature gradually returns to its normal state. In chronic drug users, permanent physiological changes may occur such that there is no longer a smooth total decay of the apparent drug-induced effects. By processing a significant number of thermal images, thermal signature markers are identified and related to standardized vascular system locations whose thermal variation are highly correlated with use of the particular substances. References may be developed for an individual, for a class of individuals grouped by age or other characteristic, or for a general population.

Detailed Description Text (105):
A general determination of substance-free vs. substance-influenced classification may be based upon data collected on the thermal effects of various substances of interest. In addition, certain substances produce characteristic results which may be identifiable from detailed analysis of the thermal signatures associated with facial minutiae, and/or with distribution statistics from those signatures. Furthermore, the rate of change at any point in time may be discriminator between chronic and recent use of each drug. Techniques for processing sequences of thermal images may enhance the visibility of bilateral asymmetrics, anomalous static conditions, and unusual time-varying trends in the thermal signatures associated with specific minutiae locations in the face to indicate activity levels of specific arteries in the brain which are known to be affected by particular drugs. Therefore, when a substance is known to affect particular functions, vascular pathways to the corresponding brain areas should be analyzed for related thermal signatures at minutiae points along the pathways, under the assumption that increased activity at the brain site will be found to correlate with increased vasomotor activity along pathways leading to that site, as evidenced by thermal changes.

Detailed Description Text (106):
In order to best compare images from different people and under different conditions, facial thermograms must be standardized and registered to common coordinates. The preferred approach is to use the standardized infrared minutiae coordinate system (SIMCOS) technique which locates standard minutiae points on each facial thermogram. In its preferred embodiment, the SIMCOS minutiae correspond to anastomoses which are connections or branchings of major superficial veins and arteries in the facial area. Approximately 175 such points exist in the face. A subset of the SIMOS minutiae which relate to blood vessel or areas of the face affected by a particular substances is selected. The substance activist at the brain site will be found to correlate with increased vasomotor activity along pathways leading to the site, as evidenced by thermal changes.

Detailed Description Text (108):
In subsequent screening of a known individual for a particular substance, his current thermal image(s) are analyzed to extract substance-active minutiae which can be seen in the available image(s). The set of thermal signatures is compared to the substance marker collection and substance-free marker collections. Measures of similarity are calculated for individual, class, or general population comparisons for each substance of interest. Various correlation associated with substance use, or with substance-free references in the system library. Normalized temperatures vs. time waveforms for each minutiae can be compared with the corresponding waveform from the reference. The waveforms are slid along the time axis until the best fit is found, since it is not known when, if at all, the person being screened may have used that substance. Another correlation approach involves sampling the thermal waveforms and producing a matrix of values, where one dimension of the matrix is the number of minutiae used, and the other is the number of temperature samples over time. The reference library can include wider matrices, involving longer time period than is practical for an operational screening system. The comparison between the collected matrix and the reference matrix would use a digital shifting and difference calculation to find the best area of match.

Detailed Description Text (114):
The image in the frame grabber and buffer is processed by the face locator 20 which determines that the image includes a single face which is in focus and of a suitable size and position. If the image is not suitable according to software criteria established within the face locator, a new image frame is grabbed and the process repeated until a suitable image is obtained.

Detailed Description Text (115):
The image is then processed by the minutiae extractor and identifier 22 which locates the SIMCOS minutiae points and extracts their positions on the image and the corresponding apparent temperatures. Additional frames are grabbed and processed for a period of time selected by the system manager.

Detailed Description Text (121):
The substance use identification and detection system requires databases of thermal signatures from substance-free and substance-related images. During clinical trials in which substances are administered under rigorous protocols, the same apparatus may be used to generate the reference databases.

Detailed Description Text (122):
A clinical trials investigator will serve as system manger. He will perform set-up and initialization of the system, the system manager interface 2, which includes a monitor or other display, keyboard, and possibly a printer and other peripherals such as a mouse which are normally associated with personal computers. The system manager must confirm the identity of the enrollee 2, and input the associated identification information into the person identifier and condition identifier database 6 within the system processor 8. Since the same person may be enrolled several times under various protocols, he is termed the "subject" to emphasize that he may have several separate files within the enrollment database 26. The subject's current and past medical history data is input to the system the first time he is imaged. During each different test involving different substances and/or protocols, the specifies of the protocol used, as well as recent medical data, including the results of urinalysis or blood tests to detect substance use, will be included in the person identifier and condition ID Buffer 6. The contents of that buffer are transmitted and stored with the results of the thermal signature extractor 24.

Detailed Description Text (125):
After the end of clinical trials, frames are extracted from the archival videotapes and used in place of images directly taken by the infrared camera. Each extracted frame is processed by the system, and the thermal signature comparator and statistical analyzer 36 selects the best matching composite signature and classifies the frame accordingly. First, the thermal signature collection of that frame is classified as better matching the composite for all substrate-free trials or the composite for all substance-related trials. Second, if the subject in the frame is judged to be substance-free, the best matching class of database 30 is then selected. If the subject is judged to be substance-related, then the best matching substance of database 32 is selected. Third, in the substance-free case, the system identifies the best-matching enrolled person's signature within the class selected. In the substance-related case, the system identifies the best-matching protocol for the substance selected. Since the true classification of each subject on the video tape is known, the performance of the system in an automated mode can thus be determined, and the error rates associated with the classification can be calculated. Improvements to the system can then be made according to standard techniques for statistical analysis, including the use of neural nets to adjust weightings consideration of the data from certain minutiae more or less than others, normalizing the thermal variations or not, and normalizing time intervals based upon the size or metabolism of each subject.

Detailed Description Text (128):
The image in the frame grabber and buffer is processed by the face location 20 which determines that the image includes a single face which is in focus and of a suitable size and position. If the image is not suitable according to software criteria established within the face locator, a new image frame is grabbed and the process repeated until a suitable image is obtained.

Detailed Description Text (129):
The image is then processed by the minutiae extractor and identifier 22 which locates the SIMCOS minutiae points and extracts their positions on the image and the corresponding apparent temperatures. Additional frames are grabbed and processed for a period of time set into the system by the system manager.

Detailed Description Text (133):
Various standard methods for locating faces in an image frame can be used. A particularly useful approach uses an ellipse detector to find relatively warm ellipses (thermal faces) within a relatively cool background. The ellipse is located

within the expected height range for humans, the detected temperature is within the expected range for human faces, and characteristics common to all facial thermograms (hot canthi regions, symmetry of the eyes, nostrils, ears, cheeks, etc.) are not violated. Each detected face in each frame is evaluated to determine if it meets the quality requirements for further processing. Requirements include the facial image being in focus, being large enough to provide adequate resolution of the facial minutiae, being oriented close enough to full face forward and being free enough of blockages including beards, eyeglasses, and intervening obstructions, such that a sufficient number of facial minutiae can be extracted from the facial image. The specific requirements are dependent upon what substances are to be detected, in how small a dose, and after what period of item. Faces which do not meet the quality requirement are not further considered. Those which are qualified are assigned unique tags.

Detailed Description Text (135):
The system is designed for stand-alone operation. IT is deployable for programmable periods of time, during which it will analyze and classify each face which appears within its field of view. The system will not routinely record or store the thermal images, although provisions are made to do that during testing and evaluation of the system in order to allow for improvements to be made in the system and compared with earlier results. The output from the system will be graphical results such as shown in FIG. 19. The cumulative detection index of the y-axis represents the number of people who the system estimates have used marijuana, cocaine, or heroin in an amount and within a timeframe which results in a residual level indicated by the x-axis value at the time of the analysis. The x-axis represents the confidence level of drug signature indication, which is related to the detection precision of the testing and analysis procedures. Separate curves indicate the specific drugs detected, and a composite survey indicates detection of any of the substances. Due to the frequent use of combinations of drugs, the composite curve is expected to be more significant than its components.

Detailed Description Text (142):
The analyzer 64 of the composite thermal signature compares each imaged person's composite thermal signature to a database of signatures associated with known substances and protocols, or with known subpopulations such as cocaine addicts or alcoholics. More particularly, a signature from a thermal signature database from deployment 66 is compared with a signature from the reference thermal signature 68 is a comparator 70, the output of which is delivered to a thermal signature classifier 72. The analyzer output is delivered to a statistical analyzer 74 for processing the thermal signatures by batch to produce an output summary to the output report generator 76 for the output device 78. A statistical sufficiency analyzer 80 evaluates the report and determines whether the analysis of the population up to that point is statistically sufficient for the intended purpose. If not, additional frames are analyzed. If the analysis is sufficient, then the system is re-initialized by the initializer 50 starting a new collection of faces and leading to a new statistical evaluation.

CLAIMS:

1. A non-invasive automated method for continuously controlling the re-aligning the position of an instrument relative to specific locations on a patient's body during a medical procedure, comprising the steps of: (a) generating thermal images of the patient using a non-invasive imaging device spaced from the patient prior to and during use of the instrument on the patient; (b) using a minutiae generator to identify minutiae in the vicinity of a specific location of interest on the patient from said thermal image, said minutiae corresponding with specific branch points of blood vessels of the patient; (c) generating a reference minutiae pattern for a stationary patient; (d) generating a reference position of the instrument with respect to said reference minutiae pattern; (e) detecting deviation from said reference minutiae pattern owing to movement of the patient and from said instrument reference position owing to displacement of the instrument; and (f) continuously repositioning the instrument with respect to said reference minutiae pattern to accurately position the instrument for the medical procedure.

2. Non-invasive apparatus for continuously controlling and re-aligning the position of an instrument relative to specific locations on a patient's body during a medical procedure, comprising: (a) non-invasive imaging means spaced from the patient for continuously generating thermal images of the patient prior to and during use of the instrument on the patient; (b) minutiae generator means for identifying minutiae in

the vicinity of a specific location of interest on the patient from said thermal image, said minutiae corresponding with specific branch points of blood vessels of the patient; (c) means for generating a reference minutiae pattern for a stationary patient; (d) means for generating a reference position of the instrument with respect to said reference minutiae pattern; (e) means for detecting deviation from said reference minutiae pattern owing to movement of the patient and from said instrument reference position owing to displacement of the instrument; and (f) means for continuously repositioning the instrument with respect to said reference minutiae pattern to accurately position the instrument for the medical procedure.

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Queries 1781 through 1830.

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S #	Updt	Database	Query	Time	Comment
S1830	U	USPT,PGPB,JPAB,EPAB,DWPI	video near offset$1 and offset$1 and (image$1 or picture$1)and offset$1 near6 (image$1 or picture$1)and jpeg	2003-07-29 16:48:03	
S1829	U	USPT,PGPB,JPAB,EPAB,DWPI	video near offset$1 and offset$1 and (image$1 or picture$1)and offset$1 near6 (image$1 or picture$1)and morph$3	2003-07-29 16:45:57	
S1828	U	USPT,PGPB,JPAB,EPAB,DWPI	video near10 offset$1 and offset$1 and (image$1 or picture$1)and offset$1 near6 (image$1 or picture$1)	2003-07-29 16:44:49	
S1827	U	USPT,PGPB,JPAB,EPAB,DWPI	video near10 offset$1 and offset$1 and (image$1 or picture$1)and offset$1 near10 (image$1 or picture$1)	2003-07-29 16:44:16	
S1826	U	USPT,PGPB,JPAB,EPAB,DWPI	video near10 offset$1	2003-07-29 16:41:45	

S1825	U	TDBD	video near10 offset$1	2003-07-29 16:38:01
S1824	U	TDBD	video near15 offset$1	2003-07-29 16:37:52
S1823	U	TDBD	video same offset$1	2003-07-29 16:37:24
S1822	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	demers and animat$5 and piecewise	2003-07-28 21:46:22
S1821	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	demers and animat$5	2003-07-28 21:45:44
S1820	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$5 same interpolat$5 same surface and graphics near3 pipeline	2003-07-28 20:58:37
S1819	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$5 same interpolat$5 same surface	2003-07-28 20:58:13
S1818	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	anmat$5 same interpolat$5 same transform$6 and surface	2003-07-28 20:57:15
S1817	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(((345/473)and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and (surfac$3 or textur$3) and map$4 and textur$3 near5 map$4 and (interpolat$4 or piecewise or piece adj wise or skinning or stitching))and animat$5) and dot near5 product	2003-07-28 13:42:38
S1816	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	((345/473)and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and (surfac$3 or textur$3) and map$4 and textur$3	2003-07-28 13:36:28

			near5 map$4 and (interpolat$4 or piecewise or piece adj wise or skinning or stitching)) and animat$5	
S1815	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(345/473) and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and (surfac$3 or textur$3) and map$4 and textur$3 near5 map$4 and (interpolat$4 or piecewise or piece adj wise or skinning or stitching)	2003-07-28 13:33:41
S1814	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(345/473) and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and textur$3 and map$4 and textur$3 near5 map$4 and (interpolat$4 or piecewise or piece adj wise or skinning or stitching)	2003-07-28 13:32:36
S1813	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(345/473) and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and textur$3 and map$4 and textur$3 near5 map$4	2003-07-28 13:29:38
S1812	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(345/473) and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and textur$3 and map$4	2003-07-28 13:28:44

S1811	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(345/473) and interpolat$5 near5 (vertices or vertex$2 or polygon$8 or mesh$3) and textur$3	2003-07-28 13:27:56
S1810	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(345/473) and interpolat$5	2003-07-28 13:26:40
S1809	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	345/473	2003-07-28 13:26:22
S1808	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	texture near3 map$4 near10 (vertex$2 or vertices or mesh$3 or polygon$7) same animat$4 same interpolat$4	2003-07-28 13:20:50
S1807	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	texture near3 map$4 near10 (vertex$2 or vertices or mesh$3 or polygon$7) and animat$4 same interpolat$4	2003-07-28 13:20:17
S1806	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	texture near3 map$4 near10 (vertex$2 or vertices or mesh$3 or polygon$7) and animat$4	2003-07-28 13:19:39
S1805	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(animat$4 near15 interpolat$4 and textur$3) and (skinning)	2003-07-28 13:16:46
S1804	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$4 near15 interpolat$4 same textur$3	2003-07-28 13:14:14
S1803	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$4 near15 interpolat$4 and textur$3	2003-07-28 13:10:38
S1802	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$4 near15 interpolat$4	2003-07-28 13:08:28
S1801	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$4 with interpolat$4	2003-07-28 13:08:04
S1800	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	animat$4 same interpolat$4	2003-07-28 12:50:43

S1799	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 near10 (dct near10 (frequency near4 domain))	2003-07-28 04:59:45
S1798	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 near10 (dct near15 (frequency near4 domain))	2003-07-28 04:59:34
S1797	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 near10 (dct same (frequency near4 domain))	2003-07-28 04:59:05
S1796	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 near10 (dct and frequency near4 domain)	2003-07-28 04:58:18
S1795	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 near15 (dct and frequency near4 domain)	2003-07-28 04:58:07
S1794	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(watermark$3 same (dct and frequency near4 domain)) and moskowitz	2003-07-28 04:56:12
S1793	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(watermark$3 same (dct and frequency near4 domain)) and wie	2003-07-28 04:54:45
S1792	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	(watermark$3 same (dct and frequency near4 domain)) and narayanaswami	2003-07-28 04:54:31
S1791	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 same (dct and frequency near4 domain)	2003-07-28 04:54:11
S1790	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	watermark$3 same (dct or frequency near4 domain)	2003-07-28 04:53:56
S1789	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	digimarc and (spatial or domain or space or imagery or database)and imagery and database and index and embedded and cloud adj cover	2003-07-28 04:50:06
S1788	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	digimarc and	2003-07-28

			(spatial or domain or space or imagery or database)and imagery and database and index and embedded	04:49:37
S1787	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	digimarc and (spatial or domain or space or imagery or database)	2003-07-28 04:48:47
S1786	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	6504571 and (spatial or domain or space or imagery or database)	2003-07-28 04:46:43
S1785	U	USPT,PGPB,JPAB,EPAB,DWPI,TDBD	6504571 and (spatial or domain or space orimagery or database)	2003-07-28 04:46:33
S1784	U	PGPB	6504571 and (spatial or domain or space orimagery)	2003-07-28 04:46:03
S1783	U	PGPB	6504571 and (spatial or domain or space)and imagery	2003-07-28 04:45:01
S1782	U	PGPB	digimarc and patch$3 and watermark and aerial and platform and map and generating and embed$4 and image$2 and indicator$1 and identif$5 and locator$1	2003-07-28 01:09:42
S1781	U	PGPB	digimarc and patch$3 and watermark and aerial and platform and map and generating	2003-07-28 01:08:23

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